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AN EXACT

Survey of the TIDE.

Explicating its

PRODUCTION } VARIETY
AND } AND
PROPAGATION, } ANOMALY,

In all Parts of the WORLD;

Especially near the

Coasts of GREAT BRITAIN
and IRELAND.

With a Preliminary TREATISE concerning
the Origine of SPRINGS, Generation of
RAIN, and Production of WIND.

With Fifteen Curious MAPS.

The Second Edition.

To which is added,

A Clear and Succinct DESCRIPTION of an
ENGINE, which fetcheth Water out of the
Deep, and raiseth it to the Height design'd,
Progressively, by the same Motion.

By E. BARLOW, Gent.

L O N D O N :

Printed for THO. WOODWARD, at the *Half-Moon* against
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PREFACE.

THE *Laws* of Motion, establish'd by Divine Wisdom in the Nature of Things, are, without doubt, uniformly and universally observ'd throughout every part of the Creation; and consequently, these *four* great Wheels of *Fluid* Nature, which I have undertaken to consider, viz. *Springs, Rain, Wind, and Tide*; must have their constant Revolutions determin'd by the same *Laws*, and be adjusted and carried on, exactly according to *Statical* Principles.

But it is equally certain, that *No Man can find out the Work that God maketh, from the beginning to the end* †; nor trace the Order of remote Causes, which lie involv'd in endless Combinations, to their first Origin, in the immense Regions of *Air and Water*: wherefore, being to treat of these *Effects*, which are so well known to us, and lie daily expos'd to our Senses; I shall not need to amuse my Reader with *Hypothetical* Conjectures: grounding my Discourse all the way upon the *Things* themselves, or such acknowledg'd *Properties* of 'em, as are sufficiently ascertain'd by repeated Experiment and Observation.

As first, It being allow'd, that the Air gravitates (as appears by the *Baroscope*) as well as Water; and Experience assuring us, that *Springs, Rain, Wind, and the Sea*, tend always directly *downwards*, unless some exterior Impediment give 'em a Deflection: Hence I may conclude, that their common Tendency that way, by their own *Gravity*, must be the principal *interiour* Cause of their Generation, or Production; and that the Three former may be traced up to their first Ori-

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gin,

P R E F A C E.

gin, by following the Tract of their constant Motion (*downwards*) revers'd; with the same Certainty, that *Rivers* are traced upwards to their respective *Fountains*, which first produc'd 'em: And whereas the *Tide* consists of an Inequality of the Sea's Surface; however it be rais'd above its natural Level, it must be depress'd again as much, by the Ponderation of its own Weight, to compleat its Tidal Motion.

But, because all direct Motion must terminate at last; and the Circulation of these *voluble Fluids* is perpetual; some exterior Agent must revolve 'em again *upwards*, contrary to their natural Propension: And since we find by Experience, that Light and Heat raise Water, in *Mists*, up to the Clouds; and by rarifying our grosser Air, swell it higher into the Sky: Hence it may reasonably be concluded, that the Rays of the Sun, by hoisting 'em Both aloft, and letting 'em fall down again; produce *Springs*, *Rain*, and *Wind*, alternately.

These *Three*, whose Appearances are much fewer and less perplex'd, I have examin'd, after a brief manner, in my *first* Treatise: as a preliminary to my *second* of the *Tide*; They all, after some sort, affecting the *Sea*; But especially the *Winds*, which immediately stir up its Surges: and more particularly those Winds which *Trade* upon the Ocean; some *periodically*, to opposite Points at several Seasons; whilst others drive its Surface *continually* Westward: Whole Origin and Course I have describ'd, in the Close of my first Treatise; according to the *Historical Observations* of that most learned and accurate Meteorologist, Dr. Edmund Halley, the *Savilian* Professor at Oxford.

Next, concerning the Exterior Agent, which stirreth up the Sea, and causeth the *Tide*: In regard the Diurnal Course of the *Moon* comes up so close, at every *six Lunar Hour's* distance, with the Terms of its *Floods* and *Ebbs*, as to argue as absolute a Dependence thereon,

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thereon, as any Effect whatsoever can have on its proper Cause; and this so remarkably, That *such a Moon makes such a Tide*, is the Navigator's common Expression; It is scarce to be doubted, but that Her Influence is chiefly concern'd in the Tidal Affair.

But whether Her proper Action be to *raise* the Sea's Surface *above*, or *depress* it *below* its natural Level, seems not so easy to determine; since its Motion, alternately *up* and *down*, may be alike occasion'd by Either.

The *Antients* generally attributed to the Moon a Power of *raising* or *swelling* the Surface of the Ocean, after the manner of Boiling Water: whence it was called the *Astus*, or Ebullition of the Sea; which they held was at *once* excited in the Parts directly under her *Meridian*, and those, *diametrically* opposite to 'em: The former by her *direct*, this by her *reflex'd* Rays. In this Opinion we find *Aristotle*, with all the *Peripatetic School*; *Strabo*, *Pomponius Mela*, *Pliny*, &c. This last Author pleasantly calls the Moon, (*) *Sydus avidum, trahensque secum haustu Maria*, &c. And *Aristotle's* Word, to express these Ebullitions, is ἀμπύρεις; which he seems to explicate by κυμάτων ἀρσεις; saying, they do (†) Συμπερὸς δὲν αἰετὶ τῇ Γαλιῶνι.

When the *Copernican* Systeme was reviv'd, many of its Favourers endeavour'd to account for the Course of the Tide from the Motion of the Earth; as, *Galileus*, Lord *Verulam*, Mr. *Hobbes*, and others: But not succeeding herein; *Des Chartes* brought in the Moon's Pressure to its Assistance: (||) making the Earth's Rotation to stir up the ambient Air into Motion, and the Moon's Interposition, between the Inside of her Orb and the Outside of our Ocean, to compress it into a Wind within our Hemisphere; which Wind, as he (mistakenly) supposes, proceeding from the Rotation of the Earth to the Eastward (the above-named Dr. *Halley* having demonstrated the contrary;) must carry with

(*) *Hist. Nat.* l. 2. c. 97. (†) *Arist. de Mundo*, c. 4. (||) *Princ. Phil.* P. 4. § 49.

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it that Portion of Air, which is incumbent on the *Eastermost* part of the Earth, forward to the most *Westerly* Points thereof (far *swifter* than a *Bullet* out of the Mouth of a *Cannon*) in *twelve hours* space: and the Tumour of Water, which it affects, must likewise accompany it through the *same* Space in the *same* Time. Which is inconsistent with all Observation; and must render the *Art* of *Navigation* altogether impracticable.

The Truth is, not only *Des Chartes*, but most other Authors who have handled this Subject of the *Tide*, have fall'n under the same grand Mistakes: which are,

1. That they imagine its *proper* and *primogenial* Tendency to be from *East* to *West*.

2. That it makes High-water in *all* Places, *where* and *when* the Moon is on the Meridian.

The quite *contrary* to both which, is found true by the best *Observation*; as I have taken occasion more amply to shew throughout my *Second Treatise*.

Wherein the Reader (I hope to his Satisfaction) will find how I have endeavour'd to lay such *Causes* of the *Tide*, as are no ways inconsistent with the *Effects* themselves, or those *Phænomena*, of which Experience and Observation has assur'd us: How, after I have trac'd its Course throughout the *Ocean* in general, I confine my Enquiries to the *Atlantic* Stem; and soon after within the Compass of the *European* Seas; whence I withdraw 'em to the *British* Coasts; and after all (for clearer Inspection's sake) describe the Tides within our *English* Channels: and have had Recourse, all the while, to *Authors* of the best Repute, and our approved *Tide-Tables*, for Matter of Fact.

This *Essay* I have the more willingly submitted to Publick View; that *Time* and *Opportunity* might, at leisure, adjust *mistaken* Circumstances; and that, by the Assistance of fresh *Observation*, and Industry of *Art*, the whole *Theory* might, at length, be improv'd into a common Stock of Useful Knowledge.

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First TREATISE.

CONCERNING

The Origin of Springs, Generation
of Rain, and the Production of
Wind.

CHAP. I.

Of the Origin, and Course of SPRINGS.

SECT. I.

*Of the Common Source of Springs, in general;
and, How they are diversify'd, by their different
Descents thro' the Veins of the Earth.*



O disclose the Source, and Origin of *Springs* in general, by considering the Constitution of the *Matter* whereof they consist, and observing the common Tract of their *Motion*; seeing they are all compos'd of Elementary Matter, (which is abundantly heavier than Air) they

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must

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must still tend downwards ; and being also of a thin and fluid Constitution, must needs insinuate themselves with Ease, into the Veins and Cavities of the Earth, how crooked and perplex'd soever ; so that to return upwards, or run Transversely, must needs be contrary, or beside their Natural Propension ; and consequently not to be admitted, but in Case of some Obstacle or Impediment, which may Exteriorly divert their Course, against their Interior Inclination.

And for Distinction's sake : 1. They are divided into *Day-Springs* ; which, either lying near the Surface of the Earth, or finding free Passages thither, break forth into the open Air, on their own Accord ; while those of the *Deep* are sunk down so low, as to require Buckets and Chains to fetch 'em up again. Next, they are call'd *Top* or *Bottom-Springs* ; inasmuch as they appear either above the Rock, which severs the Soil from the Mine, or underneath it : Moreover, *Top-Springs* differ from *Day-Springs*, in that they stagnate between the Superficies of the Earth and the Surface of the Rock, till they be open'd by the Miner ; and *Bottom-Springs*, that can be let off by Soughs and Trenches, are distinguish'd from those of the *Deep* ; which, to be drain'd by such Means, is either altogether impracticable, or absolutely impossible.

Next, it is farther observable, that all those Sorts of Springs proceed originally from the same Source ; to wit, *Rain* and *Dews*, distill'd from the Clouds : And they are diversify'd by their Transfusion thro' the Veins of the Earth, whereon they are scatter'd. For, in Case they

Course of SPRINGS.

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they be imbibed by a loose and porous Soil, they presently break forth again into *Day-Springs*; or, if their Course be obstructed by some slimy or soapy Matter, they are still exerted against the Miner's Pick, in *Top-Springs*; or else, if let down by the Chinks of the Rock, they meet him again below it, in *Bottom-Springs*; or finally, if they lie too far distant from any River, of a Lower Situation, to be Taken off practically; or else Lower than the Sea, to make that impossible; they are properly Springs of the *Deep*, and no farther to be Accounted for; the Floor they last fall upon, being Seamless, and scarce penetrable; and whether Solid, or Hollow, Uncertain: The rest will be made manifest, by respective Observations, in the following Sections.

SECT. II.

Of the Origin, and Growth of Day-Springs.

IN the Search after the Original Source of those Rills, and Currents of Water, which, issuing out of the Earth, are commonly call'd *Day-Springs*, or *Fountains*; the First Consideration that occurs, is, that their Natural Course, as consisting in Motion merely Local, & caused by the Propension of their own Weight, still drawing them Downward towards the Center of the Earth, their Course must always be upon a constant Descent, from a Higher Situation to a Lower; and so must

proceed Originally from *Rain*, distill'd from the Clouds: And if it happen, that at their Emergency out of the Earth, their Spring riseth Upwards; 'tis caused by the Curvity of their Passage, that (*Syphon-like*) pointeth that Way; while the Preponderation of the Water, contain'd in its other Arm, descending from a greater Height, forceth it to Rise, contrary to its Natural Inclination.

Hence it comes to pass, that Springs seldom break forth in Plains, or Champion-Ground, for Want of an Ascent to raise them, and a Descent to let 'em off again; but the Rain that chanceth to fall there, either stagnates into *Pools*, and *Lakes*; or if it be imbibed by the spongy Soil, it sinks into Beds of Sand, or Gravel, to be convey'd by Subterraneous Passages, to some lower Situation of Valleys and *Rivers*, that discharge it last into the Ocean; or if it be employ'd to furnish *Pits*, or *Ditches*, dug deeper into the Earth, they never rise Higher than their first Source; or the Superficies of those Plains, that imbib'd the Rain which first produc'd 'em.

But, in Case those Springs get the Advantage of a Higher Ground, to Rill themselves down into a Lower, by descending thro' the pervious Sand, or Gravel, till they break forth at last into the open Air; they run themselves off in a joint Proportion, to the Extent of Ground whereon the Rain fell, and the Capacity of the Orifice that vents 'em; so that if the Former be but small, and the Latter too large; such weak and unconstant Springs run themselves out, almost as soon as the Showers are fall'n, that replenish'd 'em.

Or,

Or, if Springs of a stronger Stream, and a longer Continuance, chance to rise upon Plains; the Eminence that feeds 'em, cannot be small, nor afar off, and seldom above a League; and the Quarry of Stone, which conveys 'em thro' its Chinks, must crop out of the Ground in the same Place; or the Bed of Clay, or Marl, that had suppress'd 'em all along, must break off, or be discontinued, to let 'em off into the open Air; at a Rate proportionate to the Veins of the Earth, thro' which they are to pass, and the Stock of Water that maintains them.

Afterwards, if we climb those Mountainous Heights, which most abound with Springs, we shall find Cause enough for 'em; and a competent Extent of Surface, to receive a proportionable Quantity of Rain, for their Supply; and Clifts of Rocks every where wide open, to receive and convey it into the Caverns of the Earth, as Reservatories to detain it; till the Chinks underneath can let it off again at leisure, for a constant Supply to water the Valleys below; perhaps for the whole Summer's Season.

And, at last to mount the Tops of those Hills, whence these Subterraneous Rivulets derive their Origin; they always occur to us upon a constant Descent, and are divided into Branches, Upwards; still becoming gradually smaller, till their utmost Extremities terminate after all, at the Surface of that Height, from whence they drew their first Source; and were Originally distill'd, by innumerable Drops of Rain, from the Heavens themselves; as being

Of the Origin, and

the first Source and Origin of all the *Day-Springs*, without Exception.

Hence it is remarkable, *First*, That Springs are never found upon the Ridges of any Hills, for Want of Ground of a Higher Situation, to distill Currents of Water to supply 'em; nor upon those Plains that are exactly Level, for Want of a Lower Descent, to carry off the Rain that falls upon 'em: *Next*, That the Springs, which break forth nearest the Tops of those Hills, are soonest supply'd with Rain, and as quickly evacuated; but upon a Lower Descent, they become slower in receiving their Recruit, and longer in spending it; whereas Those, that rise at the Foot of the Hill, run perpetually; and suffer only a Decrease in Summer, of what they Increased in Winter, which may perhaps arrive at length, to an Equality: just as Water, poured (like Rain from the Sky with Intermissions) into a Tub bored full of Holes, and filled with Sand, is soonest evacuated by Those, that are nearest the Top; which run off almost as soon, as the Infusion ceaseth; and the Lower they stand, the slower they are replenish'd, and hold out longest; whereas Those of the lower Tier, flow perpetually; and perhaps at last, without any Variation at all.

For, so it happens in the strongest Springs; which force their Rise, out of the Bottoms of the Highest Hills; especially when the Office of their Eruption, holds not a full Proportion, to the Source which maintains 'em; as doubtless it does not at *Holy-Well*, in *Flintshire*, one of the most plentiful Springs in the World;

World; which being surrounded, almost on all Sides, with very High Hills, one heap'd upon the Back of another, keeps up its Stream to the Highest Pitch, in the greatest Drought in Summer: Whereas another Spring at *Bardsea*, below the *Lancashire* Fells, in Winter, drives almost an equal Stream with it; yet decays considerably at the contrary Season, for Want of a competent Supply, to keep it up to an Equality. A convincing Argument, that the Sea, tho' adjacent to 'em Both, is neither the Common Source of these Two Fountains, nor holds a strict Communication with 'em; to keep the Former, exactly to its greatest Height; and yet let the Latter fall with so considerable an Abatement, that near a third Part of its Stream is lost.

And, to compare those Springs with those Rivers, that take their first Rise from the Tops of the same Mountains; as they are fed by the same Showers of Rain, so their Growth and Increase continue much alike; but the Manner of their Course, and its Effects, become as different: For whereas Rivers receive their Recruits in open Channels, expos'd to the Air; Springs, on the contrary, have Theirs first imbibed by the Earth, to be convey'd away thro' close Conduits, under Ground: Those still float upon the Surface of their Paths, and can only vary their Course, To and Fro; but These, that sink into the Deep, are diverted every way, into an endless Maze of Perplexity: Those fall with Precipitation, down the Valleys into the Plains, which they overflow; while These derive their Rills out of all Sorts of Metals, and Minerals, through

which they are to pass into their Reservatories, for the Summer's Season : Those, flowing all the while with open Banks and a free Passage, discharge their Floods upon every Shower ; while These, be the Feeder never so great, their Passage is so perplex'd , and streightned on all Sides, as to pass 'em off so regularly, that sometimes they admit of no sensible Variation,

Thus much may suffice, for a full Display of the Cause of those Currents, that are call'd *Day-Springs*, and break forth of the Earth into the open Air ; which, being Liquid, and following the Course of Nature, must easily insinuate themselves into the Crevices, and Caverns of the Earth ; and withal, being of a heavier Constitution than Air, must every where expel it ; and so, according to Reason, must Originally proceed from Showers of Rain falling upon a Higher Ground, which imbibes 'em ; and are actually found by Experience, upon a constant Descent till their Eruption. Let us see what is to be said of the Springs of other Sorts, which lye conceal'd in the Bowels of the Earth, till the Miner takes the Pains to discover 'em.

SECT.

Course of SPRINGS.

9

SECT. III.

Concerning the first Source, and Production of Top-Springs.

THUS far Reason and Experience being agreed about the Origin and Growth of *Day-Springs*, which arise out of the Earth into the open Air, on their own Accord; and chiefly serve for the Earth's Refreshment, amidst the Summer's Heats; and the supplying of Rivers with Water, in Droughty Seasons; we must descend to Those, which are discover'd under Ground by the Miner's Industry; and belong after a special Manner, to his Inspection.

Now as to those Rills, which are commonly call'd *Top-Springs*, tho' they jointly partake of the same Origin with those of the *Day*, and are immediately supply'd by Showers of Rain; yet they never overflow on their own Accord, either for Want of Fall into some Lower Situation; or else because they are not furnish'd with a competent Force of Water to make an Eruption: but still remain shut up in Beds of Sand or Gravel, lying between the Soil which covers 'em, and the Rock which sustains 'em; and at a competent Distance from the Surface of the Earth, to send up plentifully Steams and Vapours, to cherish and refresh the Roots and Stems of Vegetables of all Sorts.

Concerning the Production of Springs of this Sort, inasmuch as they depend on the Miner's

Miner's Pick and Spade to discover, and set 'em on foot; about the Beginning of *September*, after a Summer's Drought, when he first breaks Ground, he finds the Soil dry for a Spading deep; and so it continues, till the first steeping Shower sinks into it, perhaps an Inch, before the Next falls; which, finding the Earth somewhat dampish, pierceth it considerably deeper; and the Third, after it is much better dispos'd to receive it, penetrates deeper still; and so does the Fourth, Fifth, &c. progressively; making the Way easier, for those which follow; that showry Moisture, the lower it sinks, growing denser; yet 'tis so imbibed and incorporated with the Soil, that they grow into so clammy a Sort of Mud, that neither the One can properly be called Earth, nor the Other, Water; as long as that Month lasteth.

In *October*, that Moisture being condens'd, sinks by Degrees thro' this clammy Matter, into the looser Sand, or Gravel, whose Pores are opener to receive it, and stony Particles cannot be pierc'd; whence it becomes a separate Substance; and is actually strain'd out of the Mud, by Percolation, into Water of a Fluid Constitution; yet still remains divided into so Minute Parts, by the Smallness of its Receptacles, that it continues fix'd (as the Liquor does in a Honey-comb,) till it be squeez'd out by the Miner's Stroaks, which set it at Liberty: And having once got Vent, such crizzling Rills creep thither-wards from all Sides, especially from the Rising Ground; whence their Fall is greatest, and their Stock is most increased; and such Springs as these
are

Course of SPRINGS.

11

are dried up in a few Days; but being replenish'd by every Shower of Rain, serve to supply *Ponds* and *Lakes* of a greater Capacity.

But, sinking deeper into Beds of Sand and Gravel intermix'd, and opening vacant Spaces of a larger Size, to hold more Water; the *Top-Springs* issue out of 'em in greater Plenty; and increase, upon their Confluence with one another, at every turn, into brisk Currents; till at last, insinuating themselves into the Chinks and Crevices of the Bastard-Rock underneath, they find Caverns and Reservatories for a longer Season; but still with Intermissions in Summer and Winter, if they continue fair for any considerable Space of Time, and sometimes without 'em: They begin to rise in *October*; and hold out till a long Frost dries 'em up; and the first Thaw sets 'em on running again, and they last (with some Intermissions) perhaps till *June*; and so continue the Year round, to supply *Pumps* and *Draw-Wells*, which are their Reservatories; until Droughts extraordinary quite exhaust 'em.

But if the Soil, impregnated with Rain-Water, lye upon Clay, or Marl, or any other impervious Matter; and again, these chance (as commonly happens) to rest upon Beds of Sand, or Gravel, for any considerable Space of Ground; the Water, which descending from the Crop-side is lodg'd therein, stagnates, till the Miner's Spade, or Augur, raieth it; and then it becomes a Spring of a stronger Current, and of a longer Continuance, and is mostly perpetual; and if the Pit, or Pipe, whereby it is rais'd, proves staunch, it ascends by Counter-Libration, as
high

high as it had descended before; and keeps to near the same Stream, both in Summer and Winter, tho' never to an Equality.

And in Case the said Springs receive part of their Recruits from some adjacent *Lake*, or *River*; 'tis always, as a late *French* Author well observes, from a Higher Situation: so that still they are duly replenish'd with Rain, either at the first or second hand; forasmuch as Lakes and Rivers continually evacuate themselves, either by Flux of Stream, or Emission of Vapours; and must be replenish'd, either immediately by Rain from Heaven, or by Springs out of the Earth; as is manifest: And the same Author farther remarks, that they re-ascend to the Height of their Fountains; as he says they do in *Paris*, near the *Seine*; where they Rise and Fall with that River; and as they do near *Warrington* in *Lancashire*, within a Mile or Two's Distance from the River *Marshey*, where a Bed of Marl lies upon Sand; and no doubt but the like is done in all other Places, on the same Occasion.

Thus all *Top-Springs* consist of a Stock of Rain-Water, laid up mostly in Beds of Sand, or Gravel, between the *Day* and the *Deep*; a commodious Depository to receive it readily, upon every Recruit from Heaven; and to part with it as freely, when the *Bottom-Springs* require it: but they are only Springs of the Miner's making; or otherwise, they hold fast what they can get; having room sufficient for a Reservatory, of the Vernal and Autumnal Rains, to supply the future Expence of the Summer's and Winter's Seasons. Let us try,
and

and see how their Correlative Bottom-Springs can draw 'em off upon Occasion.

S E C T. IV.

Whence Bottom-Springs proceed; and how they are propagated in the Veins of the Earth.

TO descend from those Rills, which stagnate in Sand or Gravel, between the Soil and the Rock, till the Miner's Pick or Spade breaks open their Inclosure, to the Bottom-Springs, which are immediately derived from them; it is to be Observ'd, That the said Sand and Water lodg'd together, rest upon a Plane compos'd of sundry Sorts of Metals; as Bast, Iron-stone, White-Earth, &c. cropping out to support 'em; which mostly are of so compact a Substance, or lye so close Bedded together, as scarce to let down any Water berwixt 'em; yet Others, of a more porous Sort, are interpos'd at certain Distances; or else are so disjoin'd from their Fellows, as to transmit a Quantity sufficient to furnish Springs of sundry Sizes; according to the different Constitutions of the said Metals, or the Capacities of the Clifts, which contain 'em.

Again, the said Metals being not of Lumpish and Globular Figures, to scatter their Water every way alike, as Light passeth thro' Diaphanous Bodies; nor of a Cubical cut, to distract its Streams several ways at once; nor do they lye heap'd confusedly together,

gether, to leave their Common Course undetermin'd; but are flatted into *Plains*; with a sloping Declivity, to let their inclosed Springs descend leisurely, and carry 'em off to a new Ground: And sometimes the whole Mine lies so true, and the Series of its Beds are framed after so equal and regular a Manner, that the Miner, being inform'd what *Dip* it hath, and which way it lies, may easily compute at what Depth his Springing Vein will be open'd, at any Distance within his Compass; perhaps to a Foot at a Furlong, or to a Yard at a Mile.

Hence it is, that at what Depth, or Distance soever within his Compass, he opens his Spring with Pick, or Augur; the Orifice which he makes, presently draws all those that lye above it, and are fed by the same Vein, Thither; insomuch that Fountains, which are fed by it, are often drain'd at a Mile's Distance; while Others are spared, which rise but a few Yards off, because they derive their Streams from other Sources.

And when his Pit is to be sunk in a Bog, where *Top-Springs* most abound; to keep it dry, his first Endeavour is to stop (if possible) the Mouth of the Vein, which affects his Mine; or to take it off with an open Trench, if it be practicable, above Ground; or else to divert its Stream by a close one, underneath; (his Pit being already ramm'd about with temper'd Clay) before its Irruption; and by this Means, the Pains and Expence of tugging his Water out of the Deep with Horses and Engines, is saved; while it runs it self off to the Day, upon its own Level.

And as for the final Retreat of these *Bottom-Springs*, under the Bowels of the Earth; if it chance that those of the Deepest Sort can find no Vent into a Lower Situation, or want a Passage to convey 'em thither, they presently stagnate; and upon every fresh Supply of Rain from above, their Course recoils by *Libration* upward, towards their first Source: And in Case the Veins of Metal, which contains 'em, prove stanch and strong enough to sustain their Weight, they fill, by degrees, all the Cavities, whereby they descended, up to the Top with Dead Water; and the supervening Showers of Rain no longer penetrate their Orifices (being brim-full already), but diffuse themselves in the said Sand, or Gravel, as before described.

But, in Regard the said Cavities always lie in a sloping declining Posture, between Two Beds of Stone, or some other Metal, the One under the Other; and the Higher often becomes the *Roof*, and the Lower the *Floor* of the Mine, which is sought for: Hence, if the Miner chanceth to pare the Rock over-head too thin, or to sink his *Sump-hole* deeper than ordinary; the aforesaid Dead-Water breaks out of its Enclosure, and rusheth in upon him with so great Violence, as to endanger his Escape; and drowns his Work in a Deluge, but seldom beyond Recovery; unless that Space of Ground, which feeds those Veins, and fills their Cavities with their Distillations, proves too great for his Pumps and Buckets to master; for otherwise, their Stock of Water being once drawn out, his Work is laid dry, and he easily keeps it so; having only its
Feeder

Feeder to draw off as it comes, which cannot hurt him.

For an Instance of the former Sort; at *Scarsbrick* in *Lancashire*, the Miner, in his Search after Coal, or some other Mineral, when he had bored Twelve or Fourteen Fathom deep, thro' a close and compact Sort of Metal, and dry all the while; chancing to meet with a more Porous and Open Vein of Earth underneath, a violent Stream of Water follow'd his Augar to the Top of the Ground, and rose up a Tube at least Ten Foot higher, by the Force of its Ascent, to shew the Eminence of its Origin; and has maintain'd that Stream, without any sensible Diminution, ever since; in Proportion to the great Compass of Land whereon the Rain fell, which supply'd it: Whereas another Spring of the Latter Sort was rais'd in *Ellel* near *Lancaster*, on the like Occasion; which burst out at first with the like Force, but soon ran it self into a feeble Rill, and at last ceas'd; plainly shewing, that it deriv'd its Source from Higher Ground, than where it issued out, as well as the former; but wanted an equal Extent of Land to feed it; or a Metal of as close and stanch a Texture, to preserve it.

Hence it is manifest, that tho' the Plan aforesaid consists of Metals, how compact and close join'd together soever; yet lying in distinct Beds, each beside its Fellow; and all in the same sloping Posture, with their Upper Edges cropping out to Sand or Gravel, impregnated with Rain-Water; they must needs transmit a competent Portion of it into *Bottom-Springs*, which constantly descend from
the

the Rising Side of the Mine, as deriving their Source from the *Top-Springs*; and penetrate the Deep by those Degrees, and after the same Manner, as I have already described; (according to the daily Experience and long Observation made by a Person of Ingenuity and Credit,) without the Additional Supply of *Air condens'd into Water*, or of *Water rarified into Vapours*, in the Caverns of the Earth; much less of Rills, convey'd through its Cavities out of the *Sea* into *Bottom-Springs*; that are found Higher mounted than it, sometimes an Hundred Fathoms.

SECT. V.

Concerning Springs of the Deep; Whence they proceed, and How they are distinguish'd from the Rest.

TO descend, at last, to the Springs of the Deep, and consider 'em precisely, as contradiſtinct from Those of the *Day*; it sufficeth that they never appear to the Light of the Sun, on their own Accord; but as such, they are co-incident with *Top-Springs*, which lie conceal'd, till the Miner discloseth 'em by Force: And, inasmuch as They penetrate the Depth of all Mines and Quarries; *Bottom-Springs* dive as deep into the Bowels of the Earth as They; and so can differ from 'em only in *Name*, but not in *Nature*; yet These may be taken apart, as they are absolutely

undrainable by Soughs or Trenches, to a Lower Situation; and, consequently, must lie as low as the Surface of the Ocean it self, to find no other Reception.

Now, whether their Affinity to the Sea may cause a Participation with it; or their Submission to its Surface create a Dependence of such Springs on its Influence upon 'em: It cannot be Deny'd that *Salt-Water* may sink into the Chinks of Rocks, and insinuate it self into their Crevices, as well as *Fresh Rivers*; but never to Excess, as is found by Experience; when the Miner drives his Coal-Works, under *Tine* near *Newcastle*, for whole Miles together; and does the like under the Sea it self, on the Skirts of *Wales*, without any Remarkable Inconvenience on that Account; but rather, on the contrary, finds the Roof of his Trenches stancher, and the Chinks of the Rock stopp'd closer with Mud and other slimy Matter, than where they lie open to Sand and Gravel, in other Places.

'Tis confess'd, that *Draw-Well*s in Sea-Port Towns, and *Cistern*s dug below the Flood-Marks on the Sea-Shore, sometimes contract a Brackishness, either from an Intermixture of Salt-Water, or from the *Rock* that conveys it: But if the Springs lie above those Marks, or at more than half a League's Distance off, (as those at the *Wiches* do,) they are impregnated by Salt-Rocks, that are steep'd in Rain from Heaven, which is converted into that Briny Liquor; or else they never rise Higher than the Brink of the Sea; though they be never so near it, or spring from Caverns never so much below it, as appears by the aforesaid

Spring

Spring at *Scarsbrick*, that drains its Stream from some Fathoms below the Sea; and That at *Bardsea*, which dischargeth itself immediately into It, at the Rate of an Hundred Tuns an Hour; yet Neither of 'em, in the least, contracts any *Seaisb* Qualification; or resents its *Ebbs* and *Floods* one Jot, tho' they Border upon it.

Whereas, on the contrary, Springs of all Sorts express their strict Dependence on the Supply of *Rain*; by never failing to Rise or Fall, consequently to every Wet or dry Season of the Year; especially of *Summer* and *Winter*: Those that lie deeper, growing successively slower in receiving their Recruits, and holding out longer in spending them: Some begin to Rise in *September*; Others stir not until *October* be over; and attain not to their full Height till *February*: Or, if they begin their Increase later, they continue Rising till *March* or *April*; and Those of the last Sort sometimes, reach not their utmost pitch (as *Holy-Well* in *Flintshire*) till *Midsummer*; *Top-Springs* being sometime *Temporary*, and suffering Intermissions; but *Bottom-Springs* *Perpetual*: And the Deepest the most constant and Equal.

Thus I have travers'd the whole Course of Springs, from the *Top* to the *Bottom*; and found their subterraneous Rills at all Heights, still descending by an undiscontinued Tract, well known and closely follow'd by every *Collier*; without making any false Step, according to his best Observation: Nor have I laid any other Principles to ground my Discourse, than

Of the Origin, and

what he still supposeth, throughout his Work, to be *Self-Evident* and *Undeniable*: *viz.* That *Water* (which is the Matter whereof all Springs consist) is *Heavy* by Nature, to press their Tendency constantly Downwards; and withal of a *Liquid* and *Fluid* Constitution, to infiltrate them into *Subterraneous Passages* of all Sorts and Sizes.

S E C T. VI.

Objections against the Precedent Account of the Origin of Springs, solved.

SO manifestly (as I have shewn,) do all *Kinds* of Springs, found in the World, proceed from the Diffusion of Rain upon the Surface of the Earth; (as being diversified into several Sorts; by as different a Reception into its Bowels, and as various an Effusion out again into the Open Air;) that every rude *Collier* plainly sees; and fully understands How it is Effected; Yet Those, who wou'd have their Thoughts appear better cultivated by Reflection and Study, seem to be of a contrary Persuasion: Some raising *Objections* against Sense and Experience; and others advancing different *Opinions*, with as little regard either to the One, or the Other.

First, Whereas it is commonly Reported, that Rain never sinks deeper than Ten Foot into the Earth; and yet plentiful Springs
sometimes

sometimes occur in the *Bottoms* of the deepest Mines; 'tis a vulgar Error, As to the Former part of this Assertion, and flatly contradicts the Miner's Experience; who daily Observes, that all the Springs of the *Deep* constantly descend from the *Rising Side* of those Mines, which they affect; and derive their Source from the *Day*, as being Originally fed by Showers from Heaven; which, falling upon a spongy Soil, presently sink into Beds of Sand or Gravel; and thence descend into the Clefts of the Quarries underneath; and are transfused into the Mines below, to a Depth indefinite.

Secondly, To affirm that the strongest Springs rise out of the *Tops* of the Highest Hills, is as bold and unprov'd a Paradox as the Former; or, that they rise so near the *Tops* of those Hills, as not to afford a competent Space of Ground to gather *Rain* enough for their Supply, must needs oppose the Nature of Water; which never riseth Higher than it is forced; as well as it contradicts Reason, which tells us plainly, that Springs, which are the *Effect*, cannot exceed the Height of the Place where the Rain falls, that *causeth* 'em.

And, to pretend the Origin of *Nile* for an Instance of so strong a Spring, and so High mounted, is as disagreeable to the Account of our Modern Geographers; who derive it from the Lake *Zembre*, which exceeds three Hundred Leagues in Compass, and is the great Drain of the Upper *Ethiopia*: Or, in case any of these Rivulets, which fall into that Lake, shou'd flow from any such Spring; Why it shou'd rather be the Head of *Nile* than of *Zair*,

the third River in *Africk*, which also proceeds from the same *Lake*, is hard to conjecture : Unless to advance This as one Paradox, amongst the Rest which have been feign'd of the Origin of that River ; since no such Springs are to be found in our Quarter of the World ; where *Rivers, Lakes and Seas* most abound, to furnish 'em : To produce, I say, and insist upon such *Miracles* in Nature, and *Mysteries* to Reason afar off, contrary to the Experience of all *Europe*, must needs lessen the Credit of the Reporter.

Thirdly, It is Urg'd, that the *Tops* of those Hills, where such Springs are found, are often Ridg'd with Rocks, which hang over the Sea, and are separated Each from other ; besides, they are said to be Bare and Impenetrable by Rain. To which may be Reply'd, that if those Rocks be so pervious, as to let out Springs to spend themselves ; they must needs be as penetrable by Rain, to supply 'em : Again, if they be Bare, their Clifts are more expos'd to the Rain, and stand wider Open to receive it : Moreover, their Conduits being made of Stone, they will serve to convey their Rills into the Sea, with less Loss of Water : Finally, Those Rocks being separated from their Fellows, their Springs must also be divided into smaller Rills, in the same Proportion.

And, for an Instance of a Spring of this Nature, we have one nearer Home, in Low Furness in *Lancashire*, which dischargeth above a Hundred Tuns of Water Hourly, out of a bare and barren Rock, close to the Sea ; yet wants not, on the other side, a sufficient Supply of the Rain, that falls upon the adjoining

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Lime-Stone Hills, for a large Compass thereabouts; whose Cliffs gape wide Open into the Air, to receive and swallow All down, as soon as it falls; without putting off the least Rill any other Way.

Fourthly, It is Asserted, that in several Places of *Africk* and *America* (where is seldom Rains,) are such plentiful Springs, that they presently swell into vast Rivers: Whereas there are but Three such Rivers in all *Africk*; and Two only in that Part of *America* that wants Rain; and no Two of 'em but drains as great an Extent of Ground as the one half of *Europe*; so that they swell not presently to so vast a Bulk as perhaps our *Danube* does, which receives into its Stream Sixty Navigable Rivers, yet is not half so far Extended: Besides, there are vast Tracts of Land, in both those Quarters of the World, that lie *waste* and *desolate* for want of Springs to refresh 'em; which plainly shews there are no such Store of 'em, as the *Objector* supposeth.

'Tis true, the *Nile*, *Zair*, and *Niger*, are Rivers of the first Magnitude, and drain the greatest Part of *Africk*, and yet are seldom replenish'd by Rain; but the Two Former are once a Year so plentifully furnish'd, that their Winter-Supply holds out in spending it self, from Our *Midsummer* till the *May* following, that it be wholly let off from the *Zembre*: And the Last draws its Origin from the Mountainous Part of *Ethiopia*; where there are all sorts of Weather to maintain it, as well as upon the *Andes* in *America*, for three Hundred Leagues together; or else all *Peru* wou'd fare the worse for't: And as for those Places

where it seldom Rains, Springs must be as rare, or else the *Dews* as great to supply 'em; the Nights being constantly near *Twelve* Hours long, to let 'em fall, before they can rise so High into the Air as to become Rain; yet they are no less in Quantity, tho' not of the same Species.

When it is farther *Surmis'd*, that so small a Supply of Water as the Rain affords, wou'd scarce suffice to furnish Springs, for so continual and lasting an Expence. 'Tis *Reply'd*, that upon a just Computation, the Rivers swoll'n by the said Supply into Floods, sometimes vent more Water in *Thirty* Hours Space, than all the Springs, within that Compass, spend in a whole Year.

Again, The Showers that fall within the Space of *one* Year, wou'd, by a just Computation, suffice to stagnate all that Compass of Ground, whereon they fall, *Nineteen* Inches deep; which sufficeth to furnish a Supply for all those Rivers which rise within that Compass, during that Space of Time; with an *Overplus*, much more than to keep on foot the said subterraneous Evacuations; did not the *Vapours*, rais'd by the Sun, take off the Remainder.

Lastly, As to the *Fountain*, that in the Beginning of the World water'd *Paradise*; and the River that went out of it, which was divided into *Four* great Rivers, before our Lord had Rain'd upon the Earth: It is *Reply'd*, and may well be supposed; that God created All things (as well as *Adam* himself) in that perfect State wherein they were to continue, according to the Ordinary Course of Nature; and,

and, by Consequence the said *Fountain*, and its Rivers, were fully replenish'd with Water, as soon as they were Created; and were so to continue, till they cou'd receive a seasonable Supply of *Rain*; as well as Now they do, from one Shower of Rain till another fall; and so also till a Second, and a Third progressively; not to Multiply *Miracles*, without Necessity.

And, not to omit those *Objected* imaginary *Subterraneous Rivers*, which might possibly grow from a Defluxion of subterraneous Rills; yet *Whither* they can continually run, and *How* they can send up Springs to the Tops of Mountains, are alike Unconceivable: And, if Divine Providence has contriv'd such a Passage, to let off the Superfluity of the *Caspian-Sea* into the *Euxine*; as well as the *Guadiana*, which passeth several Leagues under Ground, to prevent a considerable Part of *Spain* from stagnating: 'Tis plain, that they were not Ordain'd for the raising Springs to such prodigious Heights, as are imagin'd; but for Other Uses.

S E C T. VII.

The contrary Opinions Confuted.

OR, in case any *Additional Supply* of Rain, beyond what is Usual, were still required to keep on foot the ordinary Course of Springs; Let us see by what Means that

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Deficiency can be made up, by Those who advance that Persuasion.

The *First* which is Assign'd, and chiefly insisted on, is the *Ocean* it self; but with very little Hopes of Satisfaction; since the Sea is *lower* than the Rivers that descend into It: And again, These are *lower* than any Part of the Land which they drain, as being always upon a constant Descent: Whence it follows, that no Spring can arrive from the Sea to any Part of the Surface of the Earth, (whence they All spring,) without rising Upwards; contrary to the Bent of its own Inclination.

And when, to weaken this Consideration, 'tis surmised, that the Ocean's Surface is *Protuberant*, swelling Higher in the Middle, than the Tops of the highest Mountains: 'Tis Reply'd, that plain Experience finds the Surface of Water always, and every where, *Level*; and it is as much against Reason, that a *Fluid* and *Ponderous* Body shou'd stand in any other Posture.

Again, To Abett this Mistake, they observe, that Ships entring into the Port make more *haste*, than they do out again; and it is no Wonder: For, coming In, they are always upon a full Speed; but going Out, they attain to that Celerity by *infinite* Degrees, which must take up Time, and Retard 'em till they be Acquired.

And whereas 'tis Urg'd, that *Hills* are discover'd *afar off* at Sea, which appear'd not *nearer* hand; 'Tis Reply'd, that the hindermost Hills, which are *last* discover'd, are really the Highest; and so from a true Prospect appear

appear afar off in their proper Place, and Overtop the Rest ; tho' the Surface of the Sea be not at all Advanced.

To correct this Mistake, They alledge, that Salt-Water so-much *preponderates* the Fresh, that the Depth of the Ocean, on that Account, will *raise* Fresh-Water Springs above the *Pique* of *Teneriff* : But of what Meral those Tubes must be made, that cou'd suffice to support Columns of Water to so vast a Height ; especially at so many Leagues Distance from the Shore, where the Ocean is so deep ; and without prove so stanch, as to convey it as many Leagues at Land, and to the like Height, without spending their Streams in the inter-jacent Plains, and Valleys underneath ; No Man can tell.

And, altho' Salt-Water be *heavier* than Fresh ; yet in case those subterraneous Passages be of too *large* an Aperture, to take off the Briny Constitution of the Water by *Percolation*, it will still retain its former Weight ; and so it can never surmount the Surface of the Sea, from whence it came : Again, if those Passages prove so *straight*, as to separate the Salter Particles from the Fresh-Ones ; the protrusive Force of the Sea's Preponderation being *Violent*, the farther it goes the more it must Abate, and so fall short of its first Origin ; while the Motion of the Water's Gravitation, so convey'd, being *Natural*, must still recover its proper Tendency Downwards, till at last it become Perpendicular.

And it is vain to have recourse to *Filtration*, to advance those Springs above their Origin ; whether

whether they be pretendedly deriv'd from the *Ocean*; or rais'd by subterraneous *Lakes* or *Rivers*, generated in the Bowels of the Earth; As if it were easier to *climb* a Hill, than to *walk* upon a Plain; or more feasible to force Water *up* a *Filter* against its own Inclination; than to drive it *forward* upon a *Level*, without any such Impediment.

For as to the *Filter*, thro' which the Stream is to pass to the Height design'd; since it has no *Attractive* Vertue to raise it; and may be made of any Porous and Pervious Matter; and is not Actuated with any kind of Motion that is Local, to *force* it Upwards against its Inclination; whether it consists of a Texture of *Filaments*, finely twisted into a Thread of *Flaxen*; or be compos'd of *Globular* Particles, mass'd as close together as common Earth is; It can only assist to *support* that Stream, while some Exterior Agent takes the Pains to *raise* It.

And, forasmuch as neither the Water can raise it self, nor the Filter sufficeth to perform that Office; the *Pressure* of the *Atmosphere* must enliven the Work, by its *Incumbency* upon the Fountain's Superficies, and drive the Stream up into the *Cotton*; and after That, sustain the impending Column; and, by an ever-repeated Impulse, still keep it in Motion: But, in regard Water is a *Fluid*, as well as *Heavy* Element; to perfect the Operation, Ambient Air must encompres the Filter *alike* on *all Sides* at once, to keep the Current within the Compass of its Enclosure; till it arrive to the utmost Pitch, that the Energy of its first Impulse cou'd raise it; without scattering
one

one Drop of its Liquor, or suffering any perceptible Distillation.

Now, in Regard the *Label*, on the descending Part from the Center of its Gravity must be alike surrounded, and compress'd by the Air on all Sides, from Top to Bottom; the inclosed Stream must, every where, meet with the same Difficulty to make any Eruption: And whereas, at its Ascent, the Threads of its Context serv'd for Steps to climb to its stated Height; Now, upon its Descent, they fit as well for Seats of Repose, to retard its Motion; so as to hold every proportionate Part of it *Equilibrions* with its Opposite; and keep the whole steady, in an equal Poise; till the Snout of the Filter reach below the Surface of the Fountain, to draw the Stagnation into a *Current* by its Preponderation.

Thus *Filtration* is found expedient for *purifying of Liquors*, by Percolation thro' some porous Matter, from Vessels of a Higher Situation to a Lower: Nor does it import, whether the Capacity of the Filter be great, or small; or the Cistern, wherein it is dipt, be of a larger, or more contracted Orifice; or that it be sunk deeper therein, or not; nay, tho' it were to the Bottom of the Sea: for (*Syphon-like*,) to whatever Height it shou'd advance its Stream, it wou'd not part with one single Drop, till it descended as low as the Fountain whence it arose: So vain it is to imagine, that *Lakes* and *Rivers*, embowell'd in the Earth, shou'd, by this Means, send forth Springs on the Tops of the Highest Mountains: When Reason and Experience makes it plain and manifest, that None can be vent-
ed

ed a Foot above its first Source; let the Filter be of what Composition, Capacity, or Application soever.

After all, the said Springs must be replenish'd by those subterraneous Conduits, upon every Increase, at the Bottoms of the Hills, before their Supply can reach their Tops; and must rather observe the *Flooding* of the *Sea*, than the *Falling* of a *Shower* of Rain: Whereas, on the contrary, Those that are Highest mounted are soonest furnish'd, and as quickly run off again, after the Shower is fall'n; without any Regard to the Sea at all; which, belike, has not been rais'd a Foot above its Natural Height, by all the Rain that ever fell, before the Deluge or after it, since the Creation.

To Others who pretend to Argue, from the *Effect* to the *Cause*, That *Intermitting* Springs, which so much resemble the *Ebbing* and *Flowing* of the *Tide*, must needs depend on the *Ocean* for it; 'Tis soon Reply'd, That their various and uncertain Motions Conclude the Contrary; some *Ebbing* and *Flowing* every five or six Minutes, as One near *Settle* in *Yorkshire*: Another every six Hours, as in the Diocess of *Paderburn* in *Westphalia*: A Third at *Peak*, about once a Week; the *Gypsies* at *Beverley*, scarce once a Year; and the Eruption of *Pendle Hill*, happens but once in an Age. An Irregularity, not deducible from any that is found in the *Ocean* it self.

Yet all their Variety of Motions, whether of *Top* or *Bottom*-Springs, is commodiously supply'd,

supply'd, and kept on foot, by *Rain*; according to their different Exigencies; by the Help of *Reservatories*, to receive and retain it from Flood to Flood; fitted with *Valves*, placed in the Veins of the *Earth*, as in the Bodies of *Animals*; to Open by their *Repletion*, and shut again, by their own Weight, after every *Evacuation*. A *Theory* that is made out by their respective Appearances of both Sorts, to be Matter of Fact.

For an Instance of a *Top-Spring*, that varies both its *Flood* and the *Time* thereof, with the Weather; That, near *Settle*, fills with every Flood a Well four Foot long, three Broad, and two Deep, in five or six Minutes; which sinks again (its Sides and Bottom being leaky) to four Inches Water, in the like Space of Time; as long as the *Wet Season* continues: Which no sooner grows *Droughty*, but the said Floods become gradually lessened and retarded; till at last the Extenuated Current, finding an easy Passage between the *Valve* and the *Orifice* (which it shuts not close) slides along its Channel at its own Rate, Evenly, without any great Increase, or Diminution, sometimes for a whole Month together: While on the Contrary,

Bottom-Springs, which are constant and equal in themselves, keep their Floods to the same Height, and Intermissions to an equal Time: And That, in the Diocess of *Paderburn*, Remarkably, complies exactly with the Ebbing and Flowing of the *Sea*, in both the said Respects; losing it self twice in four and twenty Hours, and returning back at the Interval of six Hours; and with such Violence, as

to drive *three Mills*: Yet, notwithstanding, is not in the least Influenced thereto by the Surges of the *German Ocean*; at *forty Leagues* Distance from It, and more than so many *Fathoms* beneath it: But must be supply'd entirely by the Clouds from Heaven, and suffer its Intermissions from the Means abovesaid: Its *Reservatory* collecting Water, in order to supply its Flood, with a *Valve* ponderous enough to with-hold it to its full Height; and so close, as to lose its Stream twice in *four and twenty Hours*; till the Rainy Currents force it to return back again; after the Interval of *six Hours*: With the same Constancy and Exactness, that the Sea Ebbs and Flows twice in the said Space of Time: And by the Appointment of the same *Powerful and Provident Hand*, which Created all things in *Number, Weight, and Measure*.

And, as for those Springs which, in some Measure, seem to observe the Motion of the *Tide*; because they are near the *Sea* it self, they must either lie below the *Flood-Marks*, to be Influenced by it; Or else are fed by those Rivers that raise their Floods to so great a Height, as to reach their *Level*: Or, if this general Rule admits of any Exception; it must happen, when the swelling of the *Sea*, or *River*, obstructs the Passage of those Springs; Or, at least retards the usual Swiftiess of their Descent; so as to make their depending Fountains to Overflow, or swell Higher than Ordinary.

Nor can it be any longer Objected, that those *Salt-Springs*, which are found afar off at Land, are either produced by the *Sea*, or communicate with It; since the late Disco-

very of the *Salt-Rocks* at the *Wiches* in *Cheshire*, where those Springs most abound and are impregnated by them: Nay rather, the *Sea* it self is beholden to such *Rocks* for its Briny Constitution; and doth not consist of One simple Element, but is a Compound of Two different Substances, to wit, of *Salt* and *Water*; which are easily separated, Each from the Other, by a *Filter* or *Alembick*; and as well by *Percolation*, as *Distillation*.

Others as vainly imagine, that an Excess of *Heat*, contracted in the Bowels of the Earth, evaporates *Water* (like *Smoak*) thro' the Clifts of those Mountrainous Heights into the Open Air; and insift upon the *Heat* which affects our *Baths*, to confirm their Opinion: But in this Supposition, the Springs which are to be rais'd shou'd issue out of those Clifts, on the *Rising* Side; whereas daily Experience finds them still descending towards the *Lower*; as deriving their Extraction from a more sublime Origin, Heaven it self.

Nor does the Warmer Temper of those Salubrious Fountains, evince their Heat to be contracted from Elementary Fire; as being of too Active and Diffusive a Nature to permit any *Cold Springs* to rise so near'em, as commonly to fall within the small Compass of the same Fountain; but rather derive their Warmth from the *Sulphurous* Veins, thro' which they pass; Or else, They are all impregnated, in their Passage, with several Minerals of disagreeing Spirits, which cause their Heat by *Fermentation*; like *Antimony* mix'd with Sub-

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limate

limate ; or Raments of Iron with Flours of Sulphur.

But, to allay the imaginary *Heat* of the last Opinion, it is thought by Others, that the excessive *Cold*, engender'd within the Earth, condenseth the *Air*, which is shut up in Cavities, into *Water* : And hence, They say, it is, that a Stone, or Plate of Metal, cast upon the Ground, where it is expos'd to the scorching Rays of the Sun, contracts a Moisture, by the Refrigeration of the *Air*, underneath ; whereas they rather serve for a Cover to suppress the Steam, that wou'd otherwise breath out of the Earth where they lie, and vanish into *Air* ; but for want of a free Passage upwards Thither, it is condensed into *Water*, by that Stop put to its Motion.

Or, in case either Vapours breath'd up, by an Excess of Heat, out of the Bowels of the Earth ; or *Air*, condensed in those Caverns by extream Cold, gave Springs their Origin ; the excessive Cold and Heat of the Winter's and Summer's *Solstices*, must needs respectively contribute to their Increase : But we find by Experience, that the Frost of the One dries them up, as well as the drougthy Heat of the Other ; whereas the Rain of the Spring and Autumnal *Equinoxes*, where-ever it falls, Increaseth them in the same Measure ; and after it is fall'n, leaves them upon as constant a Decay, as being their proper Cause ; which, when 'tis Apply'd they immediately *Flow* ; and when 'tis Remov'd they *Dry* up again, and vanish to almost Nothing.

And

And the *Thermometer*, at once confutes both these Opinions ; by stating the supposed Excesses of the Heat and Cold of those subterraneous Caverns, in a *Mean*, between the Extreams of *Winter* and *Summer* ; shewing manifestly, that the conceiv'd Difference proceeds purely from the different Disposition of Sense, as making an unequal Judgment at both Seasons ; excepting only in such Places, as are Actually set on Fire ; or where Mines of *Sulphur*, *Vitriol*, &c. abound : Yet their Heat no more causes the Springs that are found There ; than the Cold of *Lead*, *Alume*, &c. influenceth Those, that abound in other Places.

Lastly, Others insist upon many *Concurrent Causes*, for raising the same Springs ; or else, say They, if *Rarefaction*——, *Condensation*——, or the *Sea*——, did not jointly concur with *Rain* ; those Springs, that rise upon higher Hills than Showers can surmount ; or deeper in the Earth than They can penetrate, wou'd be weakly furnish'd ; but We have shewn respectively, in Both these Cases, that such a *Concurrence* wou'd be Impossible : Unless (as before admitted), they were surmounted by some Neighbouring Sea, or Constagnation of Water, that might supply 'em. Against which

Reply
It is *Rejoin'd* ; that *Pendle*, *Penigent*, and *Ingleborough* Hills, (which are remark'd, by *Camden*, for the Three highest in *England* :) abound with Springs, beyond any sufficient Supply of *Rain* to recruit 'em : *Ans.* Whereas the Last, which distinguisheth it self from its Neighbouring Hills of an inferior Rank, by having

its tall Head mostly cover'd with *Rain*, or *Snow*, according to the Season of the Year, (while the Rest stand Bare and Dry,) tho' its Top be Flat and Level for a *Quarter of a Mile's* Compass; yet it has not any Spring upon it, till after some Yards Descent; and There but One, which might pass thro' a Quill: On *Penigent-Hill* appears no Spring at all, till after *Thirty Yards* Descent from the Top; which, tho' it be gather'd from a great Compass of Ground that lieth above its Orifice, yet its Stream little exceeds the Former: And as for the Eruptions of Water out of *Pendle-Hill*, which *Camden* takes notice of; but One of them has happen'd within *Thirty Years* Space, and then but of an *Hour* or *two's* Continuance; and 'tis supply'd by a *Bogg*, that covers the Top of the Hill; and only breaks out after long Surfeits of *Rain*, which cannot get sufficient Vent any Other Way.

It is Urg'd after all, that the Fountain which begins the East and West *Calders* near *Townley*, riseth so exactly on the Ridge of those Hills which separate *Yorkshire* from *Lancashire*, that it runs Both Ways at once. *Answ.* And 'tis no Wonder; being a large *Bogg*, which makes a Gap between Two *Mountains*, of *Thirty* or *Forty Yards* above its Height, which supply it with Water very commodiously; and 'tis so evenly seated, or rather Rising, in the Middle, as to send down its Currents on Both Sides at Once.

Yet these *Instances*, and so represented, have been receiv'd for Unquestionable Truths by the most Curious and Ingenious Observers of the

the *Wonders of Nature* in Those Parts ; and pass'd thro' all Ages for Unanswerable Objections against what has been here advanc'd concerning Springs ; and perhaps might have continued to be reputed such till the World's End ; if farther Enquiry had not been made into the Truth thereof, upon a special Occasion : Whence may be collected, what Credit ought to be given to Those many Learned and Grave *Authors*, who relate the like *Prodigies* of other Places ; and what is to be Reply'd, to their Accumulated Testimonies : Namely, that they took their Informations at first upon slight and ill-grounded Reports ; which, being once accepted *without due Examination* by their Ring-Leaders, pass'd for current Truths with all their Followers ; Who either made it not their Business to inform Themselves better ; or were never in proper Circumstances for that Purpose.

So plainly doth it appear from all that has been Alledg'd both *Pro* and *Con*, that *Rain* abundantly furnisheth all the *Fountains* in the World with Water ; without being beholden to such Imaginary Apprehensions, as that *Air* condens'd into Water by the *Coldness* of the Earth ; or *Vapours*, rais'd by its *Heat* out of its Bowels ; much less Streams convey'd thro' its Cavities out of the *Ocean*, can in the least Affect 'em ; but rather, *Rain alone* performs the Work : Which never Falls, but gives 'em an Increase in the same Measure ; nor is Withdrawn, but they suffer a proportionable *Diminution* : So vainly do we Grope at Noon-Day for *abstruse* and occult Causes ; while the

only True One is plain and *manifest* before our Eyes.

And as for *Top-Springs*, which ever appear to the Day on their own accord; and *Bottom-Springs*, which lie absolutely buried in the Deep; the Miner no sooner discovers *Where* they lie, but he infallibly determines *Whence* they come; *viz.* the Former from Rain, distill'd thro' the Soil; and the Latter deriv'd from 'em, by such Passages as the Quarries afford, to send 'em down into the Mines underneath.: Nay, even Those which are found deepest in Places adjacent to the *Sea*, so rarely partake of its Influence, that it were as much a Paradox to say, (in general Terms,) that they proceeded from It; as to Affirm, that Mankind were a *Blind Species* of Animality; because some One Person might, perhaps, be found *Short-sighted*, in every Parish;

Which is but a weak and far-fetch'd Exception; yet the only One, that either *Experience* can find out, or *Reason* admit to this general Rule: *viz.* That *Springs*, of all sorts whatever, owe their *Substance* and Being to the *Showers* and *Dews* which fall from Heaven; their *Quantity*, both in Size and Duration, to the *Capacity* and *Depth* of those subterraneous Cavities which they penetrate; and their specifick *Qualities* to the several *Metals* and *Minerals*, which embue 'em in their Travels thro' the Bowels of the Earth: Let us proceed to the *Generation of Rain*, which is to supply 'em; and to be again supply'd by 'em Interchangeably, for Ever.

CH A P. II.

Concerning the Generation of RAIN.

S E C T. I.

Of the Common Source and Production of Rain in general.

TO proceed from the Discovery of the *Origin of Springs*, to the *Generation of Rain*; since Both alike consist of Water, as being Actually in Local Motion; the *Former*, still perpendicularly descending towards the Center of the Earth; and the *Latter*, rais'd up vertically into the Air by the Beams of the Sun; to be let fall down again by the Poise of its own Weight: This redoubled Motion, affecting not only that small Portion of Water, which supplies *Fountains* and *Rivers*; but the whole Mass of Rain, which plentifully replenisheth both *Sea* and *Land*, throughout the Universe: My present Endeavour must be, to demonstrate How, and by What farther Means, so vast a Body of That heavy Element can be continually kept in Motion; still *Ascending* and *Descending*, by an ever repeated Reciprocation.

To give the First effectual Stroke for its Motion *Upwards*; the Sun, by the Intromission of his Rays, dissolves the Continuity of the Surface of that Water whence it was Extracted; and pares off what is more subtle into small Particles of an Invisible Size; that, by a Division so Extraordinary, he may make a proportionable Increase of their *Surfaces*; to hold 'em faster, and transmit 'em with more Ease thro' the vast Tract of Air they are to Ascend: As Bars of *Iron*, drawn into small *Needles*, will swim upon Water as Chaff; and a *Milstone*, pulveriz'd and scatter'd in the Air, may be toss'd To and Fro, by every Blast of Wind, like a *Feather*: And the Reason is, because Quantity *divided*, increaseth its *Surfaces* in the same Proportion; tho' the *Substance*, or Matter contain'd therein, remains still the same, both in Bulk and Weight, that it was before the Division was made; so must also the *Subdivisions* proportionably increase in the One Respect (without meddling with the Other,) to an indefinite Progression.

But to whatever Number those Subdivisions be multiplied; or be those separated Particles extenuated never so much; yet still they remain *Heavier* than any equal Proportion of the Ambient Air; and, by Consequence, will not swim, but sink in it (as the Sediment sinks to the Bottom of Liquors;) Unless the Rays, which made their first Separation, being reverberated back from the Surface of the Earth, raise 'em up by their Rebound; and continually support 'em to the Height to which they were Advanced: So that upon
any

any Abatement, either of the Force or Motion of those Rays, the said Particles must subside, and sink down again to the Place from whence they Ascended; Those that precede still making the Way Easier, for their Followers to overtake 'em; and being Liquid, to *concorporate* with 'em into a *double* Proportion Progressively: The first Composition consisting of *Two* Particles, conjoin'd; the second of *Four*, the third of *Eight*, the fourth of *Sixteen*, the fifth of *Thirty-two*, and so indefinitely; every Concretion hast'ning their Fall, (in Proportion to their Weight,) into a greater Precipitation.

Thus Rain is Generated of Vapours, rais'd by the Sun; which become *specified* into several Sorts, in their Fall, by *Five* successive Concretions.

The 1st consists of the Primogenial Atoms of Moisture, of the *smallest* Size, and advanc'd to the *greatest* Height; which, condens'd by the Cold of that Region, and being weakliest supported by the Sun's reflected Beams, at so great a Distance from the Earth, first begin to Fall, and give timeliest notice to the *Baroscope*, of the Change of Weather; but remain near Invisible, like the Fall of *Dew* on a Summer's Evening.

The 2^d Concretion conjoins Two, or more of those Drops of the first Composition, into One; so as to overcast the Firmament with a *Foggy* Obscurity; which is express'd by the Sun, with a *Glaring Splendor* around his Disk; and the Moon, by a *Ruff* about Her of a secondary Light; while the Stars can scarcely peep thro' it; and Those, only Here
and

and There one, of the *first* and *second* Magnitude.

The *3d* condenseth into a *Misty* Obscurity; which deprives us of the Sight of those Great Luminaries, tho' there appear no Clouds, till Gusts of Wind drive 'em on Heaps; which still grow more *Opacons*, till

The *4th*, rendring 'em no longer supportable by the Air, distills a *drizzling* sort of thick and *Showry* Rain, consisting of a Multitude of small Drops; which, at

The *5th* and *last* Concretion, incorporate themselves into *Rain*, in full Proportion: And this Account of the Generation of Rain, thro' all its Descents, serves well enough for the *Summer's* Season; while the Weather is warm, and the said Vapours liquid.

But in *Winter*, when the Air is chill'd with Cold, and those Vapours are benumm'd with Ice, the Scene is chang'd; For

First, Those *Dewy* Atoms which remain'd Invisible, now bespangle the Sky by their smallest Size, and most regular Refraction of the Sun's Rays, with the glittering Brightness of a *white Frost*: *Next*, Each Two of the Points conjoyn'd, making a Line, become a *Hoar-Frost*, and create a *Fogg-like* Duskiness by their Irregularity: *Thirdly*, Each Two of these Lines laid together making a Plan; many of them interwoven into one Piece, by their fleeting Motion in the Air, (instead of a *Mist*) become Fleeces of *Snow*; and *Fourthly*, These growing more ponderous and tumbling down headlong from the Sky, rowl themselves into *Balls*; which *Fifthly*, bringing Frost along
with

with 'em into a moiſter Region; are cruſted over with Shells of Ice, into *Hail-Stones*, which makes the Operation compleat.

Now, in Regard the ſame Portion of Moiſture (which was *Rain* while it remain'd liquid) became *Hail* by Congelation; and Both originally proceeded from Particles of the ſmalleſt Size and rais'd to the greateſt Height by the Sun; and deriv'd their Pedegree from 'em, thro' an equal Number of Deſcents, by the Impulſe of their own Weight: It now occurs to ſhew, on the Converſe, How they are daily remounted, by repeated Efforts of his Rays, to the foreſaid Stations; and as it were regenerated, Each apart, without any Deduction or Dependance on the Reſt; according to their fundry Sorts and Sizes, and with Reſpect to their ſeveral Uſes.

SECTION II.

How Vapours, rais'd by the Sun to ſeveral Heights in the Air, grow, by their Deſcent, condens'd into Rain, and Hail, of as divers Sorts.

NOW, ſuppoſe the Air to be purg'd of ſuperfluous Vapours, and the Sky render'd ſerene and clear, by their Evacuations.

The *Fiſt* Effort of the Sun's Rays exhales, as it were by Reſpiration, the moſt ſubtle and minute Particles of Moiſture from all humid Bodies,

Bodies, (as well as Lakes, Rivers, and Seas,) but especially from Vegetables; which gently diffuse their Balsamick Odours thro' the Air, till the Evening Sun, withdrawing his Beams, lets 'em fall again, almost imperceptibly, in a pearly Dew, upon those Plants and Flowers, whence they were Extracted; or else they congeal into a *white Frost*, which asperseth the whole Face of the Earth with a Mealy Tincture.

The *Second* Effort of his Rays, finding the Air begin to be warm, and the whole Face of Nature better dispos'd to be wrought on, penetrates deeper into the Earth, and draws their specificck Steams and Flavours out of Plants and Herbs of every Kind; which are still advanc'd, Invisibly, to a greater Height, till they begin to subside perceptibly into a *Fogg* of Particles of the second Concretion; which subsides upon the Leaves of Trees, and upon the Straws of Corn, in *Meldews* and *Hony-falls*, if the Air be calm, and the Wind disperseth 'em not: Or else in Winter, these Balls of Dew (being now coupl'd into Pairs) become congeal'd into a *Hoar-Frost*; which breaks the more Uniform Motion of Light into a *Dusky Haziness*.

The *Third* Effort fetcheth up the Essences of Minerals, and sulphurous Exhalations, out of the Bowels of the Earth, conjoin'd with Vapours of as different Sorts; which still, upon a greater Fall, grow into *Mists*; or, while they hang suspended in the Air, become *Clouds*, being driven into Heaps by the Wind, while the Weather continues Fair; but upon

The *Fourth* Effort of the Sun's Rays, or another Lift by the Wind, the Weather changes its Complexion into *drizzling Showers*, adorn'd with Rain-bows, while they remain liquid; or into *Snow*, or *Sleet* of a Winterly Composition, mix'd with *Rain*; which, by the supervening Frost, are Cemented together, glazing the Earth with *Ice*, and loading the Trees with *Snow* intermix'd.

At the *Fifth*, when both the Earth and the Air are impregnated with Heat, and jointly conspire to reinforce this last Effort to the utmost, and raise those Vapours and Exhalations to the highest pitch; and put 'em beyond the Reach of the Sun's Power to sustain 'em any longer; they Fall at last, with the greatest Speed and Precipitation, into *Showers of Rain*, or *Storms of Hail*, in a full Proportion as to their watry Part; leaving behind 'em the more Earthy Exhalations, of a more refin'd and more spirituous Extraction, to sport themselves in *Meteors* of all Sorts, in that Upper Region; which, by the Uneasy crowding together of their Heterogeneous Matter into divers Situations, condense, and fall in as different Postures; and, taking Fire by their Agitation, shoot into *Stars*, that vanish Each into a Line of Smoak; which (if it happen by Day) leaves a *dusky Track* of Opacous Stuff in the Air, of three or four Minutes Continuance behind it, Undispers'd.

Now, as to the different Manner of the Composition of *Rain*, and *Hail*; their first Ingredients are alike Invisible Atoms, or Particles of Water of the smallest Size; which
make

make their *first* Concretion into a *thin Mixture* by a scarce perceptible Descent; as soon as the supporting Beams of the Sun (being overpower'd by their Weight) begin to yield; and the leading Particles still opening the Way for the Others to follow and overtake 'em; condense at the *second*, into a *Fogg*, at the *third*, into a *Mist*; and at the *fourth* and *fifth*, into Drops of *Rain* of several Sorts; still increasing their Size, and Precipitation, in Proportion to the Depth of their Fall; which is found by Observation to be considerably Greater in *Summer*, than in *Winter*.

But at their Conversion into *Hail*, the said Invisible Atoms of Moisture are rais'd to a higher Region; where they are quickly penetrated by the piercing Cold, and soon congeal'd into a *Hoar-Frost*; just as Raments of Steel become glowing hot in an Instant, by falling thro' the Flame of a Candle: And these frozen Particles beginning to Fall, are evenly spread upon the resisting Air, into *Fleeces of Snow*; which still devolving Downwards, are rowl'd by the Wind into *Balls*; and drawing after 'em that Frosty Air, into a warmer Climate below; are, by degrees, as it were compressed into *Hail-Stones*, of a larger Size; and wrap'd in a Coat of a more Transparent, and Icy Constitution; as *Candles*, dip'd in *melted Wax*, put on a new Investiture, upon every Immersion.

Hence it comes to pass, that *Storms of Hail* happen so frequently in *Summer*, when Heat abounds, to raise their Vapours to a competent Height; and so seldom in *Winter*, or Frosty Weather, for want of Moisture to Cement

ment 'em together, as well as of Heat to Raise 'em.

But, because the said Vapours, as soon as they Congeal, begin to Fall ; and, spreading into Fleeces, hasten their Motion, till they be rowl'd into Balls of *Snow* ; and are lastly crufted over with *Ice*, in their Precipitation : Those which are Higheft, and firft undergo these Changes, get an Advantage above the Rest, both for *Size* and *Speed*, in Proportion to their greater Defcent thro' the warmer Air ; and, consequently, must receive an Accretion of the smaller Sort, which are Cemented to 'em in their Fall : Hence it is, that *Hail-Stones* are *rugged* and *Multi-Angular*, and of a resplendent Brightness, contracted from as various a Reflection of Light, (not *smooth* and *clear*, like Drops of Water Congeal'd ;) which well expresseth their different and manifold Composition.

And, whereas the same Storm commonly pours down *Hail-Stones* of several Sorts, and Sizes ; and the larger and more rugged most-ly Fall sooner ; and the smaller and lesser Sort, afterwards ; as being not able to pierce the Air, and force their Defcent with the same Speed : And, when the Storm begins with *Hail*, and ends with *Rain* ; it is because the *Hail*, which caused that Precipitation in the warmer and lower Region thereof, brought not Frost enough down with it, to cause and continue a total and perfect Congelation.

Nay, so convertible are those Watry Vapours, that compose *Mists* and *Rain*, into *Snow* and *Hail* ; and These are again so resolvable into *Rain* and *Mists*, that all *Four* are sometimes

Of the Generation of *RAIN*.

sometimes let Fall at once, out of the same Cloud, from their several Heights in the Air; and with such Predominance either of *Heat*, or *Cold*, which as differently affect 'em; that, while *Snow* is scatter'd on the colder *Tops* of the Hills, *Rain* is often pour'd down into the warmer *Valleys* below.

Or, on the contrary, after a Frosty and *Hoary Mist* has long enshrowded the Earth from the Beams of the Sun; and they have melted the Upper-side of it into *Rain*; the Showers, which were let fall, have no sooner touch'd the *frozen* Ground, but have been Congeal'd, and glaz'd it quite over with *Ice*; and loaded the Trees with a Burden thereof, scarce supportable: Thus Vapours, rais'd by the Beams of the Sun, and let fall by their own Weight, are indefinitely diversified into all Sorts of Weather, according to the Ordinary Course of Nature; and perhaps all these *Changes* may happen within the short Space of *eight* or *ten Days*: Let us see, how any *One Sort* of Weather can be of a longer Continuance.

SECT.

S E C T. III.

How Fair and Foul Weather interchangeably succeed Each other ; and as diversly affect the Sky, at different Seasons of the Year.

SUCH is the Diversity of *Hail*, and *Rain*, and so various is the Weather depending thereon, at all *Seasons* ; that it is impossible to affix any Sort of it to whatever *Time*, or *Place* ; much less to continue it in the same State, upon reasonable Grounds, for a whole *Summer* or *Winter* together. Yet, since it sometimes so falls out ; and previous Dispositions, in a great measure, Occasion it ; and These are best taken from daily Observation ; I shall endeavour to draw a Scheme of the *Summer's Drought* in 1710, and How it broke ; compar'd with that Memorable one in 1681, (*Three and Thirty Years ago*,) in Both Respects.

The great *Drought* in 1710, began so early as the *fifth* of *April*, and lasted, without any considerable Change, till near the middle of *June* ; and persisted, without a Flood, till the Beginning of *September* ; the chief Disposition for it being a wet and tempestuous *March* ; which at once disburthen'd the Sky of an excessive *Rain*, and settled the Air in a profound *Calm* ; till towards the Month's End ; when a cold *North-Westerly* Wind congeal'd those few Clouds, which remain'd undispers'd, into Fleeces of *Snow*, with some few *Showers* intermix'd ; which left a *muddy* Sky for near a Fort-

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night within *May*; which overcast the Heavens daily, from *Ten* in the Morning till *Two* in the Afternoon; which the increasing Heat of the Air still rais'd Higher and higher, till it quite disappear'd and vanish'd out of Sight.

This Serenity continued *ten* or *twelve* Days longer; the *Weather-Glass* keeping stedfast to its utmost Pitch all the while, to shew that the Drought of the Weather was then at a stand; till near the Entrance of *June*, that the Weight of the Vapours and Exhalations overcharged the Sky, and became absolutely unsupportable: And that the Sun, having attain'd to the Height and Vigour of his *Summer's Solstice*, was as loath to let 'em Fall; till the suppress'd Air began, as it were, to reel and stagger To and Fro, under the Burthen; as plainly appear'd, by the various and Irregular Motions of some *wandering Clouds*; which the *Barometer* also resent'd by a correspondent *Rising* and *Falling*, yet near to an *Equality*; till those Clouds were overgrown, and subdued the Reflection of his Rays; and forced the Returns of the Sky as well as of the *Quicksilver*, to decline gradually towards the *Falling* Side.

Yet they stoop'd not so low as to part with any Drops of Rain, till after many repeated Descents; and Then, Here and There, contingently; till those Clouds were driven into flying Showers by sudden Gusts of Wind, which still attended 'em; and first they hit the *Ridges* of Hills, and *Heights* of Ground, that most oppos'd their Agitation; and thence drove down into the *Valleys*; where the Sun's Reflection was more broken and less able to sustain 'em, than in the *Plains*; where his Heat was

so strong and Uniform as to dispute their Fall ; and sometimes repell'd, and resolv'd 'em again into Atoms ; and so over-hastily, and in such Crowds, that their Concretions grew so fast, and they fell again with such Precipitation ; that they brought down with 'em from that frozen Region, at Midsummer, as sharp Blasts of Winds as usually blow in March ; and as cold Showers of Rain, as fall in September.

And this Struggle between the Heat of the Air on the One Part, and the Weight of the Clouds on the Other, continued all June with an almost equal Success ; and the Impulse of the Latter was so warmly repuls'd by the obstinate Resistance of the Former, while July lasted, that they mostly scatter'd Mists instead of Showers ; nor did the Rain in August so entirely prevail over the Drought, as to cause a Flood, till near the middle of September. And after all, the Sky settled not into a Serenity suitable to the Season of the Year ; but continued, as it were, by Counter-Libration, those Ups and Downs of Hot and Cold, with wet and dry Weather, which happen'd in June and first Occasion'd 'em ; whereas the Other Memorable One began later, and continued longer ; and shut up the Summer's Heats with a seasonable Rain and a great Tranquillity.

For the said Droughty Season, being deferr'd more opportunely till May, the Rain, which fell in March and April, had time enough to sink deeper into the Ground, than to be overhastily extracted into Vapours by the Sun : Besides, gentle North-East and West Winds blew alternately all the while for his Assistance,

to support 'em, till the middle of *July*; and after they had got their full load of that Opaque Stuff; which, by obscuring the Lustre of his Beams and weakning their Fervour, reduc'd the Air to a cooler Temper; those Winds also began to vary, and shift more *Southerly*, to let them Fall by degrees, and condense imperceptibly into an *Overcast*; which, finding the substrate Air too warm to admit it *Universally*, ever and anon rose and clear'd up again, the Weather remaining *Dry* for all that Season.

Till, at the Beginning of *August* it scatter'd some flying Drops, of too large a Size to be dissolv'd and too heavy to be supported; as a Preliminary Disposition to the ensuing Showers, which were put off a Fortnight longer; and the Wind, now veering constantly about the *Horizon*, with the Diurnal Course of the Sun, thro' all the Points of the Compass in *Four and Twenty* Hours; kept the Constitution of the Sky so *Equilibrions*, and those Muddy Vapours so evenly spread over it; that, upon every Repulse from the Earth, they were resolv'd into Air in *two Hours* Space, and quite disappear'd; without any Evacuation of Rain, to carry 'em off; or one Blast of Wind to chase 'em away.

Until those flying Drops gathering together into Showers, and These falling in with sudden Gusts of Wind, broke the *Overcast* into Clouds; which respectively exonerated the Air, where it was heaviest loaden in the *First Place*, and successively proceeded to exonerate the rest; so that no where was mis'd: And, in Conclusion, the Resistance of the Heat below, being

being every where weakned alike by the *refrigerating* Showers, fair Way was made for a plentiful Rain to descend *Universally*, till the Sky was clear'd, and the Ground satisfied.

So *differently* broke this Surfeit of Dry Weather from the *Former*; and Both were so long continued, after as *diverse* a Manner; and their *more and less* *seasonable* Commencements as justly Occasion'd it: The *Former* beginning in *April*, a Month too soon, and holding stanch no longer than *June*, contrasted a Change into *Foul* Weather with the Sun, upon harder Terms, when he was in full Power to resist it; than the *Latter* (which was deferr'd till *May*) did in *August*; when his drooping Beams easily stoop'd to lay down their Burthen: So that the Quarrel which was started at the *First* Change, and reviv'd at every Turn, in the *One* Case; was either wholly wav'd, or readily appeas'd in the *Other*.

Hence it is *Remarkable*: 1st, That, in both Instances, the Serenity began and ended with a *dusky* Sky, for *ten or fifteen Days* together; with an Interval of settled Weather for *five or six Weeks*; the precedent *Dusk* alike beginning, and the subsequent ending with Rain, which Occasioned the Change.

2^{dly}, That those Clouds rose every Day till Noon; and fell in the Evening, while the Fair Weather was coming on; being advanced by the *Morning-Sun*, and let fall by his *Westerly Declination*; while the Air was cool, and the Earth moist to receive 'em: But, on the contrary, when the Serenity went off, the said Cloudy Overcast still descended from the Air's upper

Region, till the Sun's Noonstead Height enabled him to repel it, whence it came.

3dly, That the *Rising Overcast*, the higher it was advanc'd the thinner it became; and more transparent; till it quite disappear'd: Whereas, on the contrary, That which *descended*, the lower it sunk and the nearer it approach'd to the Ground, grew more dense and *Opacous*, till it was repuls'd.

Lastly, That how dense and gross soever this *descending Overcast* became, yet it was usually clear'd off, by a Resolution into its primogenial Particles, in *four Hours* Space; that is, between *twelve a Clock* and *four in the Afternoon*; having the remaining *twenty Hours* allow'd it to Compound again, before it was resolv'd a *second time* by the Sun, when return'd to the same *Meridian*: Till at last it was dissolv'd into *Mists*, *Showers*, and *Rain*; and the Serenity ceas'd.

Thus *Rain*, in both Instances, was Generated of *Vapours* rais'd by the Sun; which pass'd and repass'd thro' all its Degrees of Congregation and Dissolution, recounted in this Section, by the superadded Tendence of its own Weight, within the short Space of *four and twenty Hours*: The Weather continuing *Fair*, while they were supported by his Rays, in *Summer*: Now it occurs to enquire, How such Weather can be settled in *Winter*, while his warmer Beams are withdrawn to a Foreign Climate,

S E C T. IV.

How the Weather becomes settled in Winter; and changeth differently from what it did in Summer.

FROM what has been said already of the Change of the Weather in *Summer*, it plainly appears; that it is *Then* best settled (when the Heat of the Sun is predominant) by his Support of those Vapours and Exhalations in the Air; which otherwise would discompose it: *Now*, on the contrary, the like Serenity is best preserv'd, when those Vapours and ill Humours are let fall to the Ground, and suppress'd by a hard Frost; to breed no Disturbance, till his warmer Beams lets 'em loose again into some New Commotion.

For, to resettle a *Winter's* Serenity, after the *Autumnal Rains* are Fall'n, no more is required; than that their Moisture, after it is sunk deep into the Ground, lie Congeal'd There, while he declines to his *Winter-Quarters*, to give the Air no Disquiet; till his reascending Beams begin to rouze 'em up again, towards the *Spring*, into *Foggs* and *Mists*; which the sooner it happens, the Change of the Weather grows more *Tempestuous*; and the *Rain*, being grosser, falls with greater Precipitation; Or else, if the Season be farther advanc'd, the *Frost* commonly breaks into *Fair* Weather; the same Heat which raiseth those *Mists* being enabled at once to dissolve, and support 'em.

Our last *Great Frost*, and its *sudden Thaw*, was a Memorable Instance of the *Former Sort*; which continued, with some Intermissions, from the Beginning of *November*, till the End of *January*; and, after it had enshrowded the Earth from the Rays of the Sun, for *eight or ten Days*, with a thick *Hoar-Frosty Sky*, broke so on a sudden; that the *Thames* was passable for *Coaches*, from *Westminster* to *Lambeth*, in the Morning, and for *Barges* back again before Night; the Sun's Rays having warm'd the *Backside* of that *Mist* all those Days (which was congeal'd before, and floated thro' the Minuteness of its Particles,) then (being made liquid) concorporated into several Concretions, and sunk down apace, till it had melted all the Rest.

Another Frost, about *ten Years* before This, (which continued from the *fourth* of *February* till the *twentieth Day* of *March*) froze it self out of the Ground, without *Rain*; the more enlivened Beams of the Sun, at *so far advanced a Season*, still carrying off the *Foggy Vapours* and *Frosty Exhalations*, as soon as they were rais'd; and leaving an Interval of a happy *feeding* (which was succeeded by an early *Harvest*;) before any *April-Showers* fell to interrupt it; quite contrary to the *Other*, which broke in the *Depth of Winter*, with a *hasty Rain*; the Air being then grosser and heavier, than the Sun was able to sustain.

Thus *Fair Weather* is of Course succeeded by *Foul*; and cannot be long continued, in *Summer*, without an *Excess of Heat*, to support those *Vapours* and *Exhalations* which float
upon

of *Water*, by a Dissolution of its Continuity into *small Particles*; that by the *Increase of their Superficies*, he might hold it faster, and raise it thro' the Air with more Ease: So, in the Production of *Wind*, he mingleth his purest Rays with the grossest Air, which grovels upon the Surface of the *Earth*; to make it *Lighter*, by their Composition; and withal to *swell it* to a greater Height, *Spherically*; still *Rarifying* it more and more below, and *Condensing* it as much above, as the *Reflection* of his Rays either *Increases* or *Diminishes*; and That is also renew'd by a daily Repetition; till at last they grow too weak, to sustain so heavy a Load of Exhalations any longer; which then begin to *Fall* again, towards the Surface of the Earth, depress'd by their own *Weights*.

Secondly, Touching the *different Manner* of their Descent, the *Water*, whereof *Rain* consists, being a much denser and heavier Element, than *Air*, (the *Medium* thro' which it is to pass,) every Drop thereof must pierce it with a *distinct Hole*; to distill its Showers *perpendicularly* towards the Surface of the Earth; whereas *windy Exhalations*, how gross and heavy soever they be, yet still retaining the *Natural Context* of that Element, they must drive the Subject Air *entirely down* before 'em; as the *Salt-Flood* repels the *Fresh*, when their *Currents* meet; and (the *depress'd* Air, still making a more obstinate *Resistance*) that Part of it which is the *Uppermost* must *slip aside*, to find an easier Passage *Downwards*; And the *faster* it falls (always meeting with a *greater Resistance*) it is still constrain'd to descend,

scend, by a greater *Declivity* from the *Perpendicular*; till its *Course* arrives at last to a *Level*, and becomes *Progressive* ever after; the *whole Stream* of *Exhalations* pursuing the same *Trait*; and *pushing forward* all the while, till their common *Stock* be quite exhausted: Thus the *Wind* is produc'd, by a *reciprocal Motion* of *Exhalations*; first *Ascending* *perpendicularly*, and then *Descending* again still more and more *Obliquely* by degrees, till its *Course* becomes at last *Horizontal*.

And forasmuch as the *Wind*, according to the *vulgar* Acceptation of the Word, is defined, *A Flux of the Air*, which is the *Subject* of its *Motion*; in Reference thereto, it is to be

Consider'd, *First*, that *Air* is a *Heavy Element*; as appears by the *Baroscope*, which finds the *purest* Sort *Equilibrious* to *seven and twenty Inches* of *Quicksilver*; or so many *Foot* of *Water*; and, consequently, the most *natural Motion* of the *Wind*, in Compliance with the *Tendence* of its said *Subject*, must be *Perpendicular*, towards the *Center* of the *Earth*.

Secondly, the *Wind* being rais'd *Spherically* by the *Sun*, with due Respect to our *Globe's Superficies*, must *Fall directly* towards its *Center*: And being also *puff'd up* by the *Composition* of his *Rays*, must return back as *directly* whence it came (as *Air* returns in a *Cupping-glass* when the *Flame* is *Extinguish'd*.) as soon as they are withdrawn: Beside, the *Refraction* of his *Beams*, being *strongest* near the *Surface* of the *Ground* which they fall upon; the *windy Matter* must make the *sharpest* return *Thitherward*: Hence the

the deepest Descents create the briskest Winds; as well as the sharpest Showers.

Thirdly, To decline the Course of the Wind obliquely; as the Rain, that falls indifferently on all Places, alike slides down on all sides into the Valleys, so does Wind into the same Depressions; and as Rivers of Water are directed by their Banks; so is this Flux of Air by the Situation of the Valleys, which it chanceth to fall into; the One Element, being as naturally inclined to follow the Conduct of its own Weight, as the Other; And Wind grows, by its deepest Descent, as it were into Floods, still of a larger and stronger Stream.

But on Plains and Champion Ground, where no Depressions are found to sway its Course; as the Heavier and denser Air (being Uppermost) forceth its Way thro' That which is Lower and Lighter; so the Heavier Side of any Part must draw the Lighter side-ways after it; or the weaker Side of the substrate Air must incline it to slide down that Way; while Exhalations render it unequally Ponderous, by their Composition; or the Vapours, which attend it, determine its Indifferency by Protrusion: But, both the Upper and Lower Air being withal Elastic, the Motion of the One is broken disorderly into Blasts by the Repugnance of the Other, without End or Measure; while, for want of any such Determination, the Wind runs around, at other Times, in vain to find one, till it be spent.

Lastly, the Sun, which first stirs up this Tumult in the Air, by Rarifying it below, and Condensing it above; draws it after him from
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East to West, by leaving it still *Rarified* by his Presence, for the *More dense* to follow him by its *Preponderation*: All which said Points occur to be *discuss'd* and *explain'd*, in the same Order that they are *Propos'd*.

SECT. II.

How Wind is produc'd of Air, by the Motion and Mixture of the Rays of the Sun; and How it is directed by the Situation of the Earth, on which it falls.

SINCE Wind Essentially consists of a Flux of Air; and all Motion is conceiv'd to proceed from Rest; I am to suppose the Air to be settled in a profound Calm, before it begins to Move; and shew how the Rays of the Sun first disturb its Quiet; partly by the Lightness of their Composition, expanding and rarifying it, as it were, towards a Vacuity; and partly by the Activity of their Reflection, Buoying up the Groffer Part of it in the Morning, while their Light and Heat increase; and letting it sink down again into that Vacuity, when they are withdrawn in the Afternoon; which sufficeth to answer the Wind's aforesaid Definition.

Thus the Air is rais'd by the Mixture and Activity of his Beams upon the first Approach; and falls again Perpendicularly, as soon as they are withdrawn, by the Innate Propension

tion of its own *Weight*; but withal being exquisitely *Liquid*, is as easily inclined to follow the different *Direction* of the *Ground's Declivity*, wherever it lights: Hence it comes to pass, that the *Morning* and *Evening's* Air, constantly attends the *Rising* and *Setting* Sun, with gentle *Gales*, upon the plainest *Flatts* of *Ground*, and amidst the greatest *Calms*; breathing every where, and every Way at once; and almost as *Imperceptibly* as the *Rise* or *Fall* of *Dew*; and scarce to be discern'd, but by the wafting *To* and *Fro* of the *Flame* of a *Candle*; that, *Weathercock*-like, wou'd represent the Variety of its Motion.

But, upon a considerable Advantage of *Ground*, the *descending Blasts* grow sensibly enliven'd; and if its *Declivity* be increased in *Depth*, or *Compass*; the *Wind* makes more haste down it, and spreads it self into a larger and stronger *Stream*, towards the *Falling* Side; as *Floods* are wont to swell, and subside towards *Night* into the lowest Situations, while the *Sky* is calm, and leaves 'em Undispers'd.

And, when they draw their Extraction from aloft the *Hills* which surrounds those *Plains*, their *Celerity* is increas'd, in Proportion to their *Descent*; and they slide down, successively from all Sides, into the deepest Depressions; where, like *Torrents* fed with many *Rills*, and those also swell'n with sudden *Show-ers*, they rush headlong down the *Valleys*, into the *Plains* below; and as it were *Overflow* 'em, with *Inundations* of Windy Matter; like *Rivers* over-grown with *Rain*, when their *Banks* are broken down, and their *Channels* are incapable to contain 'em any longer.

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But if it chance, that the Vapours and Exhalations, whereof the *Wind* is compos'd, surmount the *Tops* of those *Hills*, whence they derive its Origin; They *rendevouz* there a while, with a great deal of *Indifferency*; till they be broken by their own Weight, upon the *Summits* thereof, into several *Parties*; and descend as *divers Ways* at once, into Streams of as different *Determinations*, according to the *Conduct* of the many *Valleys*, they fall into; whether down into the *Plains underneath*, or they be carried *farther off* into *Foreign Countries*: As from the *Tops* of the *Carpathian Hills*, in *Hungary*; where the most *Eminent* of 'em, having scarce a *Breathing Air* upon it, gives a *Beginning* to the manifold *Streams* that gather, in the *Valleys underneath*, into *Floods* of *Air*, that become most violent and *Impetuous*.

Or, if the *Tops* of the surmounted *Hills* be *Ridged*; or many of them *continued* in One, the said *Mass* of *Condensed Air* sometimes splits itself into the *Two contrary Winds* only, which blow from each *Side* at once, towards the *Opposite Points*; as the *East* and *West Winds* frequently do from that *Ridge of Hills*, which separates *Lancashire* from *Yorkshire*; by the *Impulse* of the condensed *Body of Air*, that dischargeth it self *Both Ways*, till some *Counter-motion* of the *Air* repel it; the like being done by some *Hills* and *Winds* in *France*, and other *Places*.

Or, if the *Form* of those *Hills* be *Pyramidal*, their *Tops* being *Piqu'd* and their *Sides* *smooth*; the *Bodies* of *Wind* which surmount 'em, being *pierced*, descend *every way alike*; with

with so much *Indifferency*, that the Diurnal Motion of the Sun, rarifying the Air successively before 'em, sufficeth to draw 'em correspondently from *East* to *West*; from *Morning* till *Evening*, that He lets 'em fall; as is reported of Mount *Viso*, that over-tops the *Alps*; And perhaps the *Wind*, being drawn so far as *One half* around it, may compel the Air on the Back-side of it, to blow the contrary Way along the *Other half*, to perfect the Revolution.

But it happens much Otherwise, when a ponderous Mass of condensed Air is let fall by the Sun from the Top of a High Mountain, without any such *Predetermination*; as is done frequently, from the Top of *Parlock* near *Lancaster*; where the *Wind* tumbles down into *Wyresdale* with such Precipitation, that, by its *Rebounds* from the Bottom of that Valley, it remounts the *Westerly* Heights of Ground; and is carried aloft to near the same Height, till it fall into the *Sea* some *Miles* off; while the *Westerly Gales* have blown underneath it, for some Time, the contrary Way; as appear'd by the Clouds, riding *Both Ways* at Once.

Thus out of a profound *Calm* is drawn a *Breathing Air*, by the Beams of the Sun mixing with it; which, being enliven'd by their Activity, first ascends; and, after They are withdrawn, is let fall again by its Flux downwards; which gives it the Nature and Notion of *Wind*: And the Reflection of his Beams, being strongest near the *Earth's* Superficies, makes the lower Part of it *Lighter*, to incline it to Fall; and withal more Expanded, to make

room for its Reception: Now being thus disposed, and exquisitely *Liquid*, it must as easily follow the least *Declivity*, where it Falls; and the *Higher* it is mounted, still with greater *Precipitation*; and the *farther* the *Valleys* are extended, either in *Depth*, or *Breadth*, still grow into greater *Floods*, and Flow more *impetuously*, according to their *Direction*; as appears by those *Instances* I have produced for that purpose: Hence it is to be Concluded, that *Wind* is nothing else but such a *Flux of Air*, as I have described.

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SINCE the *Wind* is defined a *Flux of the Air*, and the *Air*, so moved, is a ponderous Element, as appears by the *Baroscope*; (which makes the Weight of the *Atmosphere*, when it is *lightest*, equivalent to seven and twenty Inches of *Quicksilver*) no more is required from the Sun, to convert it into *Wind*, Than, first to *Rarify* the *Air* more below, by the *Briskness* of the Beams near the Surface of the Earth; and swell it up *Spherically*, by the Mixture of his Rays: And afterwards, by withdrawing 'em again at his setting, to *condense* it *above*, to make it *Heavier*, to *Fall perpendicularly* towards the Center, and supply the rarified Space left behind

behind Him : Just as after the enkindled *Flax* has expell'd the Air out of the *Cupping-glass*, it returns immediately, to replenish it again, after the *Flame* is extinguish'd : And withal, since the *Sun* draws, all the while, the said rarified Space after him Transversely, into the *West*, by his *Diurnal Motion* ; the *Wind* must needs follow him Thitherward, to satisfie its above-mention'd *Definition*.

Yet, notwithstanding this *Easterly Determination* of the *Wind* ; the *Sun*, to leave it free Liberty of *Blowing* from any other *Quarter* of the *Heavens*, in this our *Temperate Zone*, (where his *Rays* are weaker, and his *Course* of a smaller *Compass* than in the *Torrid*) and also to direct its *Motion* more effectually, from every *Point* of the *Compass*, on *Occasion* ; permits it either 1st, To follow the *unequal Poise* of its own *Weight* towards the *Heavier Side* ; or 2^{dly}, To fall into the *substrate Air*, where it is *weakest*, and least able to support It.

First, Concerning the *Former Part* : To give the the *Motion* of the *Wind* both *Force* and *Point*, at the same *Time* ; the *Sun*, from his *Rising* to his *Setting*, ceaseth not to fill the *Air* with *Exhalations* and *Vapours* ; which, consisting of *Earth* and *Water*, tho' divided into the *smallest Particles*, still preponderate the *Ambient Air*, and press it downwards ; as neither growing *Lighter*, nor filling a *greater Space* by their *Separation* : Again, That windy Matter being diversly extracted, both for *Quantity* and

Of the Production of WIND.

Quality, Here and There, out of wet and dry Places ; must as *differently* affect the Incumbent Air, to move *Transversely* ; and pursuant thereto, give the *Wind* as *various* a Propension towards all the Points of the *Horizon* ; and no less effectually Here, on *Champion Grounds* ; than the Declivity of *Hills* and *Valleys* actually do in Other Places.

And, whereas *Exhalations* are so finely intermix'd with Air, as to give the *Wind* an *Interior* Tendency by their *Compositions* ; and *Vapours* are only annex'd to it, to impel it *Exteriorly* by *Protrusion* ; yet, forasmuch as their *Natural* Propension, draws 'em Both *downwards*, They jointly concur to the *Wind's Production* and *Conduct* ; seldom descending apart : After the One has *Open'd* the Passage, the Other still making more haste to pursue and overtake it ; and mutually propagate each Other : The *Wind*, by condensing the *Vapours* into larger Drops of *Rain* ; which, by growing greater, and falling faster, on the *Converse*, hasten the *Air* into *Wind*, to supply the same Space and restore the *Air's Equilibrium*, by their *Precipitation*.

Thus the *Wind's Indifferency* which way to Blow, is effectually determin'd by the *Unequal Poise* of its own Weight ; and its Flux is directed by the *Uneven Support* of the Air, which sustains it : Now, altho' the *Passive Part*, thro' which the *Active Wind* is to force its Way, be exquisitely *Thin* and *Fluid* ; and more slippery than Ice, to let it slide down over It ; and as easily stoops to its *Pressure*, on the declining Side, if gently Mov'd ; yet it grows harder by *Compression* ; and *Obstinate*, if it be urged with

with Speed and Force: And the Air (like *Water* mix'd with *Wine*, or *Balm* and *Oyl* with other *Liquors*) is never quiet and at Ease, till the Heaviest Part be Lowest seated; and all the Rest in their proper Stations, to render the whole Body throughout *Equilibrions*: Hence it is, that, as *Rivers* of *Water* are confined to their *Channels*; and their *Streams* are regulated and directed by their *Banks*, which *Way* to Move, whither to Flow, and after what *Manner*; so, in our present Case,

§. 2.

Secondly, The *Flux of the Wind* must concede to the *Favourable Disposition* of the *substrate Air*, in all those *Respects*.

First, If the *Airy Matter*, whereof the *Wind* is composed, be advanced so *High*, and the *substrate Clouds* prove so *gross*, as to render its *Motion* perfectly *Level* before it reach the *Surface* of the *Earth*; it hurries those *Clouds* along with it through the *Sky*, at near the *same Height*, at a mighty *Rate*; (Nothing that is *stedfast* or *solid* occurring, to obstruct or retard its *Career*,) notwithstanding the *Rack* may ride underneath perhaps *Transversely*, or the quite *Contrary Way*, by *Virtue* of a like *Impulse* from some other *Quarter* of the *Sky*; till all the said *Winds* subside into *Calmer Weather*: Or,

Secondly, In case the *Weight* of the *Wind* prevail, to force its *Descent* down to the *Ground* (as is usual) *Obliquely*; it rebounds again into the *Air* at near the *same Angle*; and is *Reciprocally* brought down again, by its *Preponderation*, through the *Ambient Matter*; and so *Up* and

F ;

Down

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Down, with a kind of *Undulation*; moving forward (like a full-blown *Bladder* cast upon a *Marble Table*) with progressive *Subsists*, till the *Energy* of its *first Impulse* be spent.

Thirdly, If peradventure the *Descent* of the *Wind* be so deflected from the *Perpendicular*, as, at its *Approach* to the *Earth*, to sweep the *Plain*, whereon it lights, with a smooth *Horizontal Gale*; yet presently its *Flux* becomes disorder'd, by its *Adhesion* to the *Ground*; which being fix'd, retards its *Motion* below; while the *Fluidity* of the *Air* aloft, devolves it with more *Freedom*, as to the *Upper Part*; which, like a *Bowl* cast upon a *Plain*, moves forward with *Cycloidical Furls*, one wrap'd within another, till its *Motion* ceaseth; which, like *Waves* of the *Sea* driven into shallow *Water*, *run* in headlong One over Another, as if they stumbled upon a broken *Bottom*.

Fourthly, Though the *Flux of Wind* (all the said *Impediments* being remov'd out of its *Way*) had *free Liberty* in other *Respects*, to blow to every *Point* of the *Compass*, without any *Difference*; yet it cou'd not pass forward towards any of 'em in particular, without slipping aside, and making its *Returns* to and fro alternately at every *Instant*; the *Passive Air* still making the *greatest Resistance* to the *Active Wind's Motion* in a *direct Line*, where it is most *Oppress'd*; And the *Wind* being allow'd in *Readiness*, and well prepared to slip aside into the *nearest Passage*, it creeps forward with *Serpentine Windings*, without *Intermission*: Hence the *Weather-cock* changeth its *Point* at every *Blas*; while the *Wind* passeth on its *Journey*, as a *Ship* under *sail* does its *Voyage*; which busieth

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the Rudder to keep it as close to its main Course as is possible, yet never steady.

Lastly, Superadd to these manifold Deflections of the Wind the *Elastick Force* of the Air; and those Streams, which have run silent and continuous all this while, are presently broken into rough, and frequently interrupted, *Blasts*; which grow more noisy and tumultuous at every Turn; and upon any *Resistance*, exert themselves into *brusker Efforts*, to beat down all Opposition: And after One Rush is over, they take the Advantage of the *Calm*, to recollect their Forces and prepare for Another; and so for a *Third, Fourth, Fifth, &c.* while the Tempest lasteth.

Hence it is Observable, that in the *Calmeft Air* and after the *longest Intervals*, they exercise the *greatest Violence*; and make more sudden and surprising Eruptions in the *Beginning* of a Storm, when they are *most resisted*, than after the Air is render'd *compliant* with their Agitation; and still they become more fierce, while it remains *clear and free from Vapours*, not to clog their Efforts: Yet never attain to the full Exercise of their Authority, till the Air (as in Wind-Guns) be compress'd alike by contrary *Blasts*, on all Sides together.

Hence the Motion of the Wind is render'd so *various and inconstant*, as not to be traced and delineated but by it self; yet, 'tis represented more *visibly* to the Eye, as it is *audible* to the Ear, or *tractable* to the Hand, by the concomitance of a *Train of Smoak*, chased thro' the Air by a gentle Breeze: By which, all the Diversity of *Ups and Downs, Toss and*

Fro's, Backwards and Forwards, are drawn to the Life upon the Canopy of Heaven : And, altho' they all proceed from the Few Causes, which I have already Assign'd ; yet their Efforts run so variously and contingently intermix'd at every Turn ; producing such a Diversity of odd and irregular Postures, and Figures of Inconstancy ; that no License of the Painter's Pencil, directed by the wildest Strains of Poetical Fancy, can reach to describe it at Land : And

§. 3.

Concerning the *Winds* which are raised at *Sea* ; They wander thro' the same Wilderness of *Instability* ; its Superficies being *Plain*, without any *Eminences* to give 'em Fall, or *Depressions* to direct 'em, like *Breezes* upon *Champion Grounds* : And are mov'd *To and Fro* with so much *Indifferency*, that if they be not repuls'd at their Entrance into *Creeks* and *Rivers*, by stronger *Land-Winds* ; they constantly set into 'em with the *Influx* of the *Tide*, and with its *Reflux* retire back again.

And if those *Sea-Winds* consist of stronger *Blasts*, and be withal *Outward bound* ; They are as much beholden to the *Heights of Rocks*, or *Boldness of the Shores*, for their *Force* and *Speed*, as if they had *Blown at Land* : And for their *Horizontal Determination*, they depend no less on the *Flux of the Streams* and *Currents* underneath, while they keep within the *Soundings* ; than *Land-Winds* do on the *Declivity of Hills*, which give 'em Fall ; and on the *Cavity of Valleys*, which receive 'em :
And

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And are alike *diversified*, with Respect to Both, as to their *Sorts* and *Sizes*, as long as they are contain'd within the Limits aforesaid.

But, if those Winds be rais'd so far off at Sea, that neither *Coasts* nor *Currents* can increase their *Force*, nor influence their *Direction*; the Sun, by the *Uniform Reflection* of his Beams from the Ocean, performs *Both* no less Effectually; by raising an *Effluviuum* of Vapours and Exhalations into the Air, in as great Abundance, while he is *Present*; and letting it fall down again in his *Absence*, with as much Precipitation at Sea, as any where else: And by shifting his *Annual, Menstrual, and Diurnal Motions*, their own Ponderation still pursuing his Course, gives 'em an endless *Diversity*, conjoin'd with an absolute *Determination*; the Ocean's Superficies being *plain* and *smooth*, to open a *free and easy Passage* for every Blast, which the *rough and rugged Surface* of All things else as *Obstinately resists*; That makes them, at Sea, the most *constant* and *Uniform* of all Other, and to reach the *farthest Distance*; and with what *Variety*, more hereafter.

Finally, The *Wind* as well as *Rain*, both at *Sea* and *Land*, depends upon so many *various* and *Contingent* Circumstances, throughout the *Temperate Zones*; that as those *Showers*, spoken of before, were *dispers'd* Here and There, by the Clouds, with an *indefinite Diversity* of *Quantity, Quality, and Duration*: So their concomitant Blasts of *Wind*, were proportionably *diversified* in the same Respects: But add thereto this farther Consideration; *viz.* That every small Portion of *Air*, whereof those Blasts consist, is *indefinitely Compressible*; on the One Side,

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Side, by what *drives* it *forward*; and on the Other, by what *resists* it; and they must exert their *Elastick* Effort, with so *different* a Speed and Force against that *Restraint*; that perhaps no *Two* of 'em were ever the *same*, in *all* those *Respects*, since the *Creation*: Now, to add *Force* to their *Variety*;

S E C T. IV.

Of the Production of Storms and Tempests.

AL L that has been hitherto Discours'd of the Nature of *Wind*, and the several Determinations of its *Course*, is no more than Ordinarily happens, on all Occasions, in Reference to the *Poise* of its own *Weight*, inclining it to *Fall*; and the previous *Dispositions* of the *substrate Air*, to admit and direct it, as to the Substance of its Motion: And, whereas I have all along Treated the *Exhalations*, whereof it is compos'd, as *Principal*; and *Vapours*, whereof *Rain* is made, only as *Accessory*: Being now to describe *Storms* and *Tempests*, which equally consist of *Both*, either *conjoin'd* or *apart*; I am to respect 'em as such: And, in Regard *Vapours* are *visible*, and *Exhalations* are not; to begin with the Former, to explain the Latter which are *invisible*, as consequent to 'em by way of Explication.

Now, as those *Rainy Vapours*, when, by a longer Continuance of *Fair Weather*, they are rais'd *Higher* than Ordinary; as they are ad-
vanc'd

wand'd in Height, so they are enlarged, and swell into Clouds of a greater Compass, from the daily Access of fresh Recruits, and this Visibly: We may infer, that their concomitant Exhalations do the like, and Embody themselves, tho' after their Invisible Manner: And as those Clouds of Vapours sometime grow to Overcast the Heavens; 'tis reasonable to subsume, that these Bodies of Exhalations become Co-extensive with 'em; even after Both, by their greater Expansion, are vanish'd quite out of Sight: Whence it follows, that as those Clouds become visibly,

1. Storms of Rain; which Fall suddenly, and are soon spent: And that Overcast suites with
2. Tempests of a longer Continuance, and a larger Extent: So, by Parity of Reason, these Exhalations must supply both Storms and Tempests, as to the Windy Part: Let us see how the Operation is perform'd, in every Respect.

§. I.

First, Concerning the Production of a Storm: The Vapours and Exhalations provided for it, begin, even while they are yet Invisible, to tend towards the Center of their Gravity, where the Lines of their Accumulation are the longest, and consequently make the deepest Impression into the Air underneath: And the Rest declining Thither from all Sides at once, (as Water poured into a Tunnel, sinks into its Spout,) they multiply their Concretions into the greatest Drops, which condense at last into a Cloud: Where they are discharged headlong into a Storm, till (their Evacuation exceeding their Concretions) the Alleviated Air shuts itself up again;

again; while *the rest* of the Stormy Matter, which remains, tending towards *the same Place*, prepares it self for *another Eruption*.

For, the *First Effort* of the Storm, having carried off all its *Watry Part* that was *dispos'd* for it, and every Drop, as it fell, leaving the Hole *shut thro'* which it pass'd; the *Wind*, that pursued it before, is now *put to a stop*; and the Air is rendred *stanch and serene*, till the *Remaining Stuff*, which was left *unprepared*, tending to the *Center* of the *precedent Evacuation*, and crowding into a *Narrower Compass*, repeats *successively* all the *aforesaid Concretions*, till it be discharged after the *same Manner*, pursuant to the *Former*; and so a *Third Effort* succeeds the second, and a *Fourth* the third progressively, one following another with the *like Intervals*; till the Sky be quite rid of all *superfluous and troublesome Matter*, to give the Air any farther Disquiet.

And, in case the *Welkin* be dispos'd to let more Storms fall, in *several Places* at the *same Time*, they breed no *new Disturbance* in the Air, while they follow the *Course of the Wind*: But if they *vary* from it *divers Ways*, the Ambient Air becomes *tumultuous* on their Occurrences: And if their *Motions* prove *Adverse* to one another, their *Rencounters* grow *more violent*; whether *so directed* at their first Eruptions, or induced, by *their own Weight*, to fall into some *Emptiness* in the Air below; where they *Insult* each other *so outrageously*, as, in their Congress, to *rid up Oaks by the Roots*; and *overthrow Castles*, by *shocking the Earth* and *sapping their Foundations*: Nay, sometimes *swallowing up whole Armies*, by *assaulting 'em* from the

Four Quarters of the Heavens at once, with an irresistible Indignation.

When but One single Storm, how fierce soever it be, sets against the Wind, the Conflict is not so sharp, being much abated by the Defendant, as the yielding Side; yet becomes more Dreadful, by the Addition of Fire-Arms to their Fury, especially amidst the Heats of Summer, while the Air is, on all Sides, impregnated with sulphurous and combustible Matter; which Both Sides sweep together in their Encounter; and by compressing it into a Ferment, and overheating it by their Agitation, makes it take Fire, and discharge it self in Claps of Thunder; which, being involv'd in the manifold Furls of the Compressing Clouds; each Crack breaking the Shell of its Inclosure, gives Fire to another of the same Rank, till all be discharged in Order at the Congress of their Encounter; as if the Fronts of their Battles fir'd their small Shot upon each Other.

And if it so chance, that any of the Cavities, between the Fronts of those Embodied Clouds, be not so Enfolded within the Rest; but directly Extended, and as it were, drawn out into a long hollow Tube; the Train of Ethereal Gunpowder, inclosed therein, taking Fire at the Upper End, presently discharges a Thunderbolt of most refined Matter out of the Lower; as quick as a continued Rarefaction and Lightning can drive it; and much swifter than a Ball of Lead passeth out of the Mouth of a Cannon; and withal it is of so subtle and penetrative a Nature, and well fitted to do Execution, especially where it finds most Opposition; as sometimes

times to melt the *Sword* and spare the *Scabbard*.

This *First Discharge* being over, presently succeeds a *Second*; and this is back'd with a *Third, Fourth, Fifth, &c.* as long as their common *Store of Ammunition* holds out to maintain the *Fight*; for the prevailing *Storm* beating back the *yielding Wind*, and still encountering the *fresh Supplies* of fiery Matter, while it brings up the *Rear*; They jointly fill the *Air* with repeated *Volleys of Shot*, till the *assailing Storm* be spent in the Pursuit; and the *defendant Wind* be so reinforced to *resist* by its *Retreat*; that Both Sides after all are well content to *relieve* with a *drawn Battle*: The *Air's Equilibrium*, for which they engaged, being at last perfectly *Restored*.

§. 2.

Thus the strongest *Storms* are soonest spent; if they be not *prolong'd* by *Intervals*, before their *Supplies* of Matter be quite *Exhausted*; and their *intermitting Fits* grow sometimes into *Chronical Distempers* of the *Air*, when their *scatter'd Clouds* spread into *Overcasts* aloft the *Mountains*, and become a *Boundless Ocean* of *Wind and Water*; without any other *Direction*, than to follow the *Propension* of their own *Weight* towards their *heaviest Side*; or that which the *substrate Air* is least able to support: And, being once *sway'd that Way*, they are carried down the *same Declivity* thro' the *Air* ever after;
1. Either according to *their own Breadth*; so, as at once to involve *whole Nations* in a *Tempestuous Deluge*; 2. Or only in *Part*, as following

lowing the *special Impulse* of some *Exterior Agent* that *first* set 'em on foot; and that Part protruding a *Second*; and this a *Third*; the *same Impression* is carried on to the *Rest* progressively, as long as a *Train of the like Dispositions* continues in the *Air* to receive and encourage their Motion. Now, in regard *Tempests* are commonly compos'd of *Wind and Water*; with *Flashes of Fire* intermix'd; and still some One of 'em is *predominant* above the *Rest*: Take here an *Instance* of every Sort.

Of the *First Sort*, whose chief *Ingredient* is *Wind*, was *That horrid Tempest*, which some *Years* ago, raged so dreadfully in the *South of England*, and drove the *Sea* over so much *Land* in the *West*, and threatned *London* with a greater *Devastation*, by the *Overthrow* of some *Buildings*, than was caus'd by *Fire* in the *great Conflagration*: And pass'd afterwards *beyond the Sea* as far as *Denmark*. It must needs have been *fomented* and encouraged all that *Way*, by the *same Windy Disposition* of the *superintending Air*, which *first* set it on foot in *Cornwal*, near the *Land's End*, to carry it forward all the while till its *Stock* was spent, and the *Hurry* was blown over.

Of the *Second Sort*, which chiefly consists of *Rain*, was *That prodigious Storm of Hail* (or *Rain congeal'd*) which pass'd soon after, on the 29th of *April*, thro' *Lancashire* and *Yorkshire* in *two Hours* Space, from the *Irish Sea* to the *German Ocean*; pouring down *Stones* all that way of *eight or ten Inches* Circumference, and some *eight or ten Inches* long; and of all *Shapes* and *Figures* imaginable, to the great Wonder and
Astro-

Astonishment of the Beholders : Such was the *Favourable Disposition* of the Air all along for this Storm, as to continue the *Impression* of its first Impulse, according to the *same Direction*, from Sea to Sea ; the *Motion of the Wind*, as it pass'd from the *One Extreme* to the *Other* in so short a Time, being next to a *Calm*.

And as to the *watry Vapours* whereof this Storm consisted, they being driven, at their first Concretion, disorderly into *Unequal Heaps* by tempestuous Blasts of Wind ; And again, suffering a *more irregular Composition* by the Shock of *Thunder* ; concorporated in their Fall into greater and more unequal Balls of *Moisture*, as long as they remained *Liquid* ; but drawing after 'em a *frosty Air*, they became *Congea'd* ; and after that, being precipitated into a *moister Region* below, were *Cemented together* into an *Icy Constitution* ; and became *Form'd* as they grew larger, into the *Oddest Shapes* that *Precipitation* and *Chance* cou'd possibly occasion.

Lastly, That *stupendous Commotion* in the Air, which so much damnified *Holland* that it blew down all the *Steeple*s in *Utrecht* (that of the *Cathedral* only excepted,) and reduced the *Body of the Church* to a *Heap of Rubbish* ; and endanger'd *Amsterdam* to the same Fate : As it alike consisted of *Vapours* and *Exhalations*, with the *Storms* of the *Two former Sorts* ; so it was distinguished from 'em by additional *Flashes of Fire*, and *Smoak* ; to express in *Thunder* and *Lightning* the utmost Fury that *Fire* and *Water* cou'd exercise upon one another ; and *Both conjoin'd* upon all things else, in order to their *Destruction*.

Now, to *distinguish*, after some manner, a Storm from a Tempest, which alike proceed from a Stagnation of Vapours and Exhalations intermix'd: The Former seems at first to break out of the Sky thro' a small Cloud, as it were out of a Bottle of a narrow and contracted Orifice; but presently spreads itself to a greater Compass, and dischargeth its Fury with so great Violence and Precipitation, that it is soon over: But the Tempest slides thro' the Air with a sloping Declivity, as one Plain does off another upon the like Declination; and becomes of a longer Continuance, and larger Extent: Yet Both are agreed to follow some previous Determination, to direct their Motion forwards progressively: Whereas, on the contrary, the Spout and Hurrican always begin with a Calm, and end in a Circumgyration; according to the Remarks commonly made upon 'em; and which are laid down at large in the Ensuing Section.

SECT. V.

Of the Production of Whirlwinds, Spouts, and Hurricans.

HAVING consider'd the Motion of the Wind, as being either conducted by the Course of the Sun; or byass'd by the unequal Poise of its own Gravity; or drawn aside by the Declivity of the Surface of the Ground whereon it falls: It remains to Enquire, to what Point of the Compass

pass it wou'd steer its Course, in case of a pure Indifferency in all those Respects; which may happen in a Calm, upon a Plain, in a Summer's Morning.

In this Case it is to be Observ'd, that as soon as the Rising Sun begins to warm the last Evening's Dew into a Morning's Mist; if the Ground, whence it is rais'd, be throughout of the same wet or dry Constitution; the Air grows by Degrees grosser and more Opacous, in the like Proportion, without any other Discomposure: But if, on the contrary, it be variously interspers'd with Lakes or Boggs, to charge the Air unequally with their Effluvioms; it seems to become somewhat Uneasy, fleeting gently To and Fro; and advancing higher into a cooler Region, begins to break into the several Consistences of Vapours and Exhalations; and the more subtle and Aqueous Part still Ascends, and Rarifies into the purer Air; while the grosser and Terreous Matter sinks alike in it, being condensed by its Refrigeration.

And withal, being contracted into a lesser Compass, those Exhalations separate into distinct Bodies; as having been diversly furnish'd from the adjacent Places; and being Becalm'd turn round in vain, to find out some special Direction; while their devolving Spires, by hastning their Descent (Periwinkle-like) draw each into a narrower Compass; and twist themselves at last into almost so many Points: But when they reach the Bottom, they unfold themselves and spread again spirally; and Those which fall upon Water, according to their different Incidences, draw as great a Diversity of Figures upon its Superficies, running through all the Conick Sections;

Sections: While those which fall upon *Land*, pick up *Leaves* and *Sticks*, Here and There, in the *Woods*; and *Straws* and *Stubble* in the *Fields*; which they scatter and disperse again, with as irregular a *Diversity* of *Curvilinear Motions*; till the first supervening *Blast of Wind* carries off the *Scene*, and spoils their *Sport*.

But if the *Calm* happens to continue, till those *Mists* be drawn up into *Clouds*; and these again be *Evaporated*, as to their watry *Part*, into *Air*; Each of them leaves in the *Sky* a dusky *Obscurity* of *Exhalations*, of a more inseparable *Composition*, behind it; which, being more ponderous than the *Common Air*, sinks a while, *Perpendicularly*, down it; till the suppress'd *Part* growing more *Condens'd* below, and making a greater *Resistance* to their *Descent*; Those *Embodied Exhalations* are forced to slip aside *Obliquely*, to find an easier *Passage Downward*: But which way soever they tend, still meeting with more *Resistance*, they deflect their *Courses* more and more towards the *Center* of their *Gyrations*; where, the *Motion* being slowest, their *Matter* becomes most ponderous, to draw 'em *Thitherward* till they become *Circular*: And the leading *Part* of each *Division*, drawing down after it its concomitant *Body* of *Exhalations* (*Spirally*;) by the same *vertiginous Tract*, they become so many *Whirlwinds*; which increase their *Speed* at every *Turn* till they reach the *Ground*: And then being determin'd, either by some previous *Declination* of the *Air*, or by the *Declivity* of the *Earth's Superficies*, whereon they *Fall*; they move forward with a *progressive Circulation*, ever after; just as *Straws* or *Leaves* cast into a *Whirlpool*, contract the same *vertigi-*

nous Motion, and continue it down the Stream progressively, till they be quite Dispers'd.

Thus a small Quantity of Moisture, hois'd up into the Sky and let fall down again, becomes a Whirlwind; but, being only the Production of one Morning's Sun, especially at Land and in Our cool Climate; it wants both Height to Fall, and Weight of Vapours to drive the Air into any farther Disorder: But, on the contrary, at Sea, where the Surface of the Water is throughout Uniform to yield an equal Supply of Moisture on all Sides at once; They must, upon a longer Continuance, spread more evenly, like a Canopy, over the whole Face of Heaven; and be of too large a Compass for the said Whirling Motion; and for want of other Determination, as an Unsupportable Load, must at last break down a Sallyport by main Force; and Tumultuously rushing into it from every side, must croud themselves into a Spout; and disem-bogue their Stream down a Pillar of Water into the Sea; till the Tumult surceasing for want of a farther Supply, the Top of it (which before seem'd to reach the Heavens) is let fall at last, and Immers'd in the Ocean.

Hence it is constantly observ'd, that, for several Days before the Spout chanceth to fall, the Surface of the Sea continues Smooth and Even, to furnish more Vapours by its uniform Reflection: Besides, the Air remains profoundly Calm, not to drive 'em into irregular Heaps of Clouds, and occasion their untimely Fall: Moreover, the whole Face of Heaven appears Serene and Clear, not to hinder the Motion of the Sun's Light or Heat, from raising 'em to their

their full Height ; and holding 'em steady throughout their Expansion over the whole Firmament, their Burden is render'd throughout alike supportable, by the Equality of their Dispersion ; and every where Invisible ; till at last growing too Ponderous, and the Sun's Beams too weak to support 'em, a Breach is made ; and, all crowding thither, they condense into a Cloud ; and are hurried into a Spout by their Precipitation ; the leading Part drawing the whole Mass of Vapours after it ; till the oppress'd Air be quite disburthen'd of its Load ; and that vast Expansion of Vapours, that oppress'd it, be Exhausted.

To describe the whole Appearance, according to Observation ; before the Cloud (which is an infallible Prognostick of the ensuing Storm) be visible, is discern'd a dusky Obscurity in the Sky of a thin Rain, hastening from all sides towards the Center where it is to fix ; and the Sea's superficies becomes plain underneath through the Pressure of the Air, which designs the Compass wherein it must Fall ; which soon grows rough again, with the Disturbance that attends it ; and contracting the same whirling Motion, condenseth the preliminary Drops of the Storm, (which before were thin scatter'd by their Gyration) into a thick sort of Rain, which seems to ascend out of the Waves : As a Fog which falls on a Summer's Evening, condensing first below, seems to rise again, though the Vapours which augment it, really descend all the while : And the said Cloud, stooping from above still lower, meets the Other which seems to rise ; and they both concorporate at last into a Pillar of Wind, and a Stream of Water intermixt ; which

spreads itself more and more upon the Surface of the Ocean, *Spirally*; as long as their common Stock of *Vapours* and *Exhalations* can hold out to maintain it.

Such *Defluxions* or *Cataracts* of Water from the Sky, are commonly call'd *Spouts*, from their *Warry* Composition, and *Perpendiculars* for their directer *Tendence* towards the Center of the Earth; while others, which are of a more *Airy* constitution, are as properly named *Hurricanes*, from the *irregular* Disorder and *Fury* of their Motion; as consisting mostly (if at Land) of hot and dry *Exhalations*, and *sulphureous Steams* of Minerals; and are so impregnated with the Beams of the Sun, as to Ferment and take Fire upon every small Agitation: Or, if they be raised at Sea, the brackish *Vapours*, that are exhaled from it, soon become a sultry Air; which, alike intermixt with his Rays, become a combustible Matter; and at every Turn, send forth *Lightning*; which, being involv'd in the surrounding Clouds, upon every Eruption, make Claps of Thunder; which are discharg'd, in Peals, one upon the back of another, after a Furious and dreadful Manner.

To calculate in some Measure, the unconceivable Fury of this raging Meteor, from the Mass of the Matter whereof it consists, and the Height whence it descends: The Former probably extends to a hundred Leagues in compass, and to a Depth proportionable; which, having made a Breach through the sustaining Air, crowds it self into that small Cloud call'd Ox-Eye, by hastning thither on all sides at once; and condensed into an unsupportable Load,
forceth

forceth its Way through that narrow Passage downwards, for a Thousand or Fifteen Hundred Fathoms; as from the Top of the Teneriff down into the Sea; accelerating its Speed all the while, perhaps to equalize that of a Flash of Gunpowder out of the Mouth of a Cannon, and be able to do the same Execution.

And descending all the while through a Medium impregnated, at so sultry a Season, with sulphurous Matter, drives it on Heaps, and involves it within its spiral Folds; till, either compress'd by so close a Confinement, or overheated by too much Agitation, it takes Fire, and dischargeth it self in Thunder and Lightning, into Clouds of Smoak. And, after it reacheth either Land or Water to obstruct its Course, it fulminates at last, to break down all Opposition; either by main Force, if it be erected of Stone, or dug out of Quarries; or else dissolves the most solid and compact of Metals, by the acuteness of its Parts, and by Menstruums proportion'd to their specifick Natures; according to the different Qualities of the Minerals whence they are extracted.

And, to continue the Storm, lest the Force of this fiery Meteor should abate, by a greater Expansion; its unfolding Spires, by encompassing more Air, still takes in new Matter; which serves for Fuel to increase the Flame, as long as the Ethereal Exhalations hold out to pursue its Course, and furnish it with fresh Recruits; and the Tumult ceaseth not, till the Air's Magazine be drain'd of such sulphurous Matter, for a considerable Compass.

Conclusion,

THUS the Spout and Hurrican are rais'd alike, by the last and strongest Efforts of the Sun's Rays; the Former consisting chiefly of cold and moist Vapours; and the Latter of hot and dry Exhalations: and at Land they are commonly extracted according to their different Constitutions; the One, out of dry and desert Places, where Sulphur most abounds; and the Other out of Bogs and Fens, where Moisture is predominant: And at Sea, where Salt and briny Vapours are exhaled, in the greatest Measure, and for the largest Extent; the Air remaining Calm all the while, to receive 'em Evenly; and Undisturb'd, not to drive 'em into Heaps; the Sky being throughout Serene and Clear, to leave the Sun the free Exercise of his Heat and Lustre; and withal to Advance and Support 'em at the highest Pitch, over the whole Expansion of the Firmament, as far as it is Visible; and this both according to Reason and Observation.

Hence it comes to pass, that off the Coast of Guinea, at four Degrees North Latitude, where there is almost a perpetual Calm, Spouts most abound; especially in August, when the Sun is vertical, and his Rays perpendicular, to draw up a greater Quantity of Water, and support it longer at its greatest Height: Again, at the Caribbee, where Islands lye thick in the Sea to furnish an abundance of Exhalations, as well as Vapours; after the Trade-wind is lessen'd gradually into a Calm, the Sun raiseth the fiercest

fiercest *Hurricanes*, consisting alike of *Air* and *Water*; and, altho' they fall not *Periodically*, at certain *Seasons*; yet always, when the *Calms* are more frequent than ordinary; and those *Tempests* that usually rage on the Coast of *Coromandel*, and the *Southerly Isles* in the *Sea of China*, so constantly fall at the End of the *Westerly Monsoon*, that they are commonly call'd *The breaking up of the Monsoons*; so that every where a *Calm* indispenfably attends 'em.

And it is to be farther noted, that those three Places, tho' most obnoxious to *Spouts* and *Hurricanes*, yet they are seldom found in their *Confines*; as in the *Gulph of Arabia*, where the *Monsoons* intermit not, tho' it be continued to that of *Coromandel*; nor amongst the *Antilla's*, where there is commonly a *Southwest Wind*, tho' they lye next adjoining to the *Caribee Islands*; nor upon the *Equator* on the aforesaid Coast of *Guinea*, where there blows a strong *Westerly Wind* almost perpetually: so that where there is no *Calm* there is no *Hurricane*, let all other *Dispositions* for it be what they will.

And as for those *Spouts* or *Hurricanes* that happen out of the *Tropicks*, where the *Sun's Rays* are less able to *Raise* and *Support* 'em at a considerable height in the *Air*; they most commonly *Ascend* by such heights of *Ground*, as are prominent to those *Seas*; as near the *Cape of Good Hope*, and the *Pique of Teneriff*, that their *Vapours* and *Exhalations* may climb up the *Hill* with more facility, having the one Foot fixt upon it, than to mount properly of themselves into the *Air*; and those which at first make the least *Appearance* in the *Air*, as being *highest* mounted,

mounted, still become by their greater Fall, the most Furious and Dreadful.

Nor can it rather be imagin'd, that the Force of any Rarefaction made in the Air can displode so sudden a Push of Wind, as to drive a Hurricane into so tumultuous a Distraction; or that Eolus had bagg'd up those Blasts in Carriets of Leather, till, all on a sudden, they broke stitches with their Inclosure; yet their Down-fall from so great a Precipice does naturally occasion it: Or that a Whirlwind, by some violent Concussion of the Sea, hoyleth up so many hundred Tuns of Water in so short a Space, to feed the Spout; rather than that a Triton laves 'em out of the Ocean, and Bottles 'em up till their Vessels burst: Whereas the Sun's Rays draw 'em up dispers'd, till their Confluence brings 'em down again at leisure and with Ease: Nor that any other Reservatorium, either of Wood or Stone, besides their uniform Expansion over the Firmament in minute Particles, lodges 'em invisibly there, till their Measure be compleat: since neither Wind can possibly raise one discernable drop of Rain, nor the Air hold it stedfastly up, for one single Moment, without letting it slip through their Fingers.

Such is the Affinity of Rain and Wind in general; and their respective Motions are so nearly related, that the Generation of the One mostly becomes the Production of the Other; the same Operation of the Sun's Light and Heat, commonly serving to effect 'em both; raising jointly their Vapours and Exhalations as high, and sustaining 'em as long as the Force of his Rays

Rays can hold out to support 'em : But after that, they are beholden to the Declivity of Hills, to direct their several Motions ; and to the Concavity of Valleys, to give their Showers and Blasts a different Conduct : And, as for the specified Distinctions of Storms and Tempests (which are higher mounted,) on the One part ; and of Spouts and Hurricans, on the Other ; I have sufficiently shewn, how the Former are easily reduc'd to, and explicated by recourse to the unequal Byass of their own Gravity, or the uneven Yielding of the supporting Air : And that the Later contract their whirling Motion, purely from the Want of any such special Determination : So that it only remains, for Illustrations sake, to bring the Truth of what has been already concluded of the Accord of Rain and Wind, by Reason ; to the Test of plain Sense and daily Observation.

S E C T. VI.

Rain and Wind Accorded by the Weather-glass.

NOW to shut up the whole Account I have given of the Production of Rain and Wind, in the Two last Chapters, with One recapitular Close ; To illustrate all that I have said upon this Subject, by bringing it to the Try of our Senses and Experience, 'tis expedient to consult the Baroscope : which, as an equal Balance, by weighing the Air in one End of the Scales, against a Counterpoise of Quicksilver

Quicksilver in the Other, plainly shews the Ponderation of the Atmosphere at all times ; and consequently how our Theory of the Sun's raising Water into Vapours, and Air into Exhalations ; and letting 'em fall again into Rain and Wind, corresponds with the Rise and Fall of the *Quicksilver*, as being their proper Effect.

First, We find by Experience, that after the greatest Evacuation of the Air, the *Quicksilver* stands to 27 Inches ; yet, as soon as the Heat of the Sun raiseth the least Fog or Mist, it presently resents it with a Blebb in the midst of its Tube ; where it has most Liberty to rise within it self, before it has got Strength to lose its Adhesion to the Sides of the Tube ; but when the Heat abates, it returns to its former Level, by the Depression of its own Weight ; and sinks lower into a Dimple, if the Air's Evacuation continue ; which serves for distinctive Remarks of Fair or Foul Weather to ensue ; but a sudden Shock of the Tube restores it either Way, to the true Height of the present Season.

Secondly, When the Sun, by his repeated Beams, redoubles his Force, and adds a correspondent Quantity of Vapours and Exhalations to the Former ; and withal, raiseth 'em jointly to a higher Station ; the *Quicksilver* advanceth in the Tube, in both Respects at once, in the same Proportion ; as a daily Prognostick of fairer Weather ; which is no sooner discontinued, than those Fogs and Mists, that first appear'd, become Rain and Wind, by their higher Fall and deeper Descent ; which the *Quicksilver* farther resents at a correspondent Rate, with

with a longer Descent and greater Precipitation.

Thirdly, In regard the Constitution of the Air is *Fluid*, and the Vapours and Exhalations wherewith it is charged, *Heavy* and *Ponderous*; and by consequence, the *Superficies* of the *Atmosphere*, which they compose, naturally *Even* and *Level*; so as not to lye *parallel* to the Surface of the Earth underneath; which is solid and *rugged*, and still more *depress'd* towards the Sea: Hence it is, that the *Quicksilver* stands *highest* in the *Baroscope*, when 'tis nearest to its *Shore*; as supporting the *Longest* and *Heaviest* Column of Air, in proportion to the increase of the *Thickness* of the *Atmosphere*: Hence we find there the *sharpest* Wind and most intense Rain, as falling down a greater Precipice.

Fourthly, Whereas it is again found by Observation, that the *Quicksilver* never ascends higher than 31 Inches; nor descends lower than 27, be the Situation of the Place what it will: We have the *Weight* of the *Atmosphere*, as simply consider'd; and the *superadded Load* of Vapours and Exhalations, *Geometrically Stated* and Compared, as 4 to 27; the *mean Space* between 'em serving for a *Scale*, to measure the several Degrees of *Fair* and *Foul Weather*, as it were by Inches; and (were the *Bore* of the Tube enlarg'd, and fill'd with *Water* instead of *Quicksilver*) it wou'd weigh the different *Ponderations* of Air at their several *Seasons*, as it were by Ounces, with the greatest Exactness.

Fifthly, In consideration that the said Vapours and Exhalations, whether they *Ascend* or *Descend*, still retain the same *Weight*, as con-

sisting

sisting of a like Portion of Matter ; yet differently affect the Baroscope, and more in Fair than Foul Weather ; as being easier to sustain any portion of Weight than to raise it ; and again to let it fall than sustain it : Besides, any quantity of Matter, by a repeated Division increasing its Surface, and becoming more Temble ; the Rays of the Sun (while those Vapours and Exhalations retain their invisible Size) can hold 'em fast : But when they begin to compound together, as growing too compact to be supported any longer, and thereby Alleviating the Air, let 'em slip, and give the Quicksilver free leave to descend.

Sixtly, Since the said Vapours and Exhalations retain their invisible Size, as long as they are on the rising Side ; the Air must hold 'em in suspense at their greatest Height for some time ; and after that, let 'em sink downwards by protracted Degrees, till several Concretions have considerably alleviated the Air : so that the Quicksilver has opportunity to give us timely notice of the ensuing Rain, several Hours before it happen : And if the sultry Heat underneath rarifie 'em again before they approach the Earth, the Fall of the Quicksilver may prevent it several Days, nay sometimes Weeks or more ; and upon such Repetitions, the Quicksilver pays constant Attendance on such Changes in the Atmosphere, by Rising and Falling alternately all the while.

Seventhly, It is remarkable, that the Air, which suffers the said Alterations, being extremely Fluid ; and the Atmosphere, wherein they are stirred up, of a Thickness proportionate, to allow it upon any Commotion, free Liberty

to rowl it self again into the *easiest* Posture : Hence it is, that the *Prognosticks* of *different Weather*, commonly extend farther than where the *Change* is actually made ; as when the *Weather-glass* in *Lancashire*resents the *Fall* of *Rain* in *Yorkshire* : And sometimes the *Aerial Evacuations* are vastly *extended*, that discharge their *Burthens* within a *small Compass*, as happens in *Spouts* and *Hurricanes* ; and sometimes quite contrary, as in the *Burning* of *London* ; which rais'd the *Quicksilver* both at *Paris* and in *Lancashire*, higher than it has been observ'd in either Place ever since.

Eighthly, In case the *Baroscope* falls lower than the *Temper* of the *Weather* seems to require, by my present Account it is occasion'd by the *Wind* ; which *raising* the *Clouds* *re* and *fro*, alleviates the *Atmosphere* by their *Agitation* : Besides, the *Wind* blowing *Horizontally*, must needs divert their propension *downwards* its own way ; and the *Higher* the *Wind* riseth, the *Lower* the *Quicksilver* falls ; and when the *Wind* is quite fall'n, it must return to its former *Height* : Hence it follows, that it must stand *Highest* in the *longest Drought* and *calmest Weather* ; and fall *Lowest* in the *Depth* of a *Rainy* and *Stormy Season*, when the common *Stock* of *Vapours* and *Exhalations* is *Exhausted*.

Lastly, Seeing the *Quicksilver* stands no higher in *Summer*, when the *Weather* is *Hottest*, and the said *Vapours* and *Exhalations* most abound ; than it does in *Winter*, when the *Air* is most intensely *Cold* and *Dry* ; and has not that *Mals* of *Rainy* and *Windy Matter* to be *sustain'd*, nor the *Sun* to support it : Hence I must needs infer, that the *Atmosphere's Gravitation*

tation grows more propense for want of his reverberated Rays to alleviate it by Rebound; and draws its Summer's and Winter's Ponderation towards an Equality; But upon a farther Consideration, that tho' it be Compos'd of the grossest Air, 'tis throughly Rarified by the Summer's Heat, and alleviated by the Horizontal Motion of the Wind; and Condensed again, by the Winter's Cold, to its natural Grossness; to restore it to the proper Exercise of its Gravitation: Which cannot fail to adjust its Summer's and Winter's Pressure upon the Baroscope, to a perfect Equivalence at both those Seasons.

So exactly does the Rise of the Quicksilver in the Baroscope describe the Weight of its Counterpoise of Vapours and Exhalations, rais'd in the Air by the Beams of the Sun; whose Ponderation sinks 'em down again into Springs, Rain, and Wind, with a Dependance upon an endless variety of contingent Circumstances, within the temperate Zones: Whence it occurs to discuss, how, on the Contrary, the Conduct of the Sun's Course alone prevails in the Torrid; to fix the said Variety into so Steadfast and Setled an Influence upon the Motions of the Wind, both as to Force and Point, as to render 'em either Periodical or Perpetual.



C H A P. IV.

Of the Motion of the WIND, as depending on the Course of the SUN.

SINCE the Heat of the Sun, both *Raiseth* and *Supporteth* the Air, inasmuch as it is the subject Matter of the *Wind*; and solely disposeth it to *descend* again, meerly by the Composition of his *lighter* Rays with the *heavier* Air, *puffing* it up *Spherically*, and letting it *sink* alternately by *Condensation*, when they are *withdrawn*, as it were, to fill up the *Vacuity* left behind 'em: And, in regard the *Sun* at once both *Enlightens* and *Warms* one *Hemisphere* of the *Globe*, and turns around it in *Twenty Four Hours*; it must, *Cæteris paribus*, draw the *Wind* after it by the *same* Means and the *same* Way, in *all* Places *successively*, from *Pole* to *Pole*; in compliance with its *Westerly* Motion.

But not at the *same* Rate; running a *Thousand Miles* an *Hour* upon the *Equator*, with respect to the *Earth's* *Superficies*; which, at the *Poles*, are shut up in a *Point*; from whence increasing his *Speed*, pariform to the *different Lengths* of the *intermediate Parallels*; and the *Swifter* his *Course* grows, moving the *Air* still more and more effectually; the *Wind*, adhering to his *Diurnal Course*, upon its *Advantage* to about *Thirty Degrees* of either *Latitude*,

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tude,

tude, blows to the *Westward* perpetually ; especially at *Sea* ; where no Land-Impediments fall in its Way, either to obstruct or divert it.

And although, pursuant to his Diurnal Course from *East* to *West*, (which is so *Swift* and *Direct* between the *Tropicks*) the *Wind* moves constantly towards the same Quarter ; yet still with due regard to his *Annual Declination*, it deflects more *Northerly* or *Southerly*, according to the different Seasons of the Year ; without a Dependence on any other Cause ; inasmuch as its Blasts soar aloft in the Air, where its Flux is most *Uniform*, and easily inclined to follow those *solar Impressions* ; but, in regard its *natural Tendence* declines it towards the Center of the Earth, and it falls at last upon the Surface, either of *Sea* or *Land* ; it must in some Measure, be *Regulated* by the Conduct of their *Situations* ; especially at *Land*, where its Surface is rough to hinder its Speed, or *oblique* to deflect its Course.

Again, notwithstanding the *Water's* Superficies be *smooth* for the *Wind* to glide easily over it ; and of its own Nature *preponderates* the incumbent Air, which is much *lighter*, and consequently apt to float upon it, without ruffling its Plain into any Disorder ; yet, in regard they are both *Liquid Bodies*, to cleave close together, and are withal effectually apply'd to each other, by the *superincumbent Atmosphere* ; the superjected *Wind* and the substrate *Sea*, must mutually stir up each others Motions ; the Former by its *Weight*, and the Latter by its *Volubility*, where it has room to rowl ; and by consequence, the *Flux* of the

Sea

Sea must share with the Rays of the *Sun*, in their sway over the *Wind* between the *Tropicks*, and very Effectually too ; when the *Space* of their Cohesion is of a large Extent ; and their joint Motion is Constant and Perpetual.

Hence it is effected, that the same *Wind* which was First carried *Westerly*, by the *Diurnal* Course of the *Sun* ; and now Secondly, is declined, by his *Annual* Motion, more North and South ; Thirdly, Is often deflected more obliquely by the Inclination of the *Shores* ; and Fourthly, Is return'd back again Periodically, from near the *Opposite Points*, by the *Sea's* Situation ; which is finally, (by the concurrence of its Flux underneath) carried perpetually quite contrary to the *Diurnal* Course of the *Sun* (which first set it on Foot,) even upon the *Equator* it self, for *Five Hundred Leagues* together.

Now the Flux of the *Ocean*, sharing with the Motion of the *Sun*, in his Conduct of *Sea-Winds* in general within the *Tropicks* ; and Both being alike concern'd in the Management of the *Trade-Wind* in particular ; it falls very opportunely to shew, what respect that *Wind* bears to their joint Direction in several *Seas*, at what *Seasons*, and on all *Occasions* ; for an easy and expedient Transition from my past Discourse of the Course of the *Wind*, to my ensuing Treatise of the Motion of the *Sea* ; by a suitable Mixture of Both in One, in this Chapter ; before I venture upon those which are Peculiar to the *Ocean* it self ; as that of the *Tide* is, which depends upon quite different Causes : Here I shall endeavour to demonstrate, how much the *Trade-Wind* is beholden to the

Motion of the *Sea* ; and *there*, in what respect the *Sea's* Motion depends on the *Wind* ; producing all along *some Instances* for that purpose, in their proper Places.

S E C T. I.

Of the Motion of the Trade-Wind, and its dependance on the Course of the Sun.

WHEREAS all this while, I have train'd up the *Wind* thro' its *Minority* from its first Production, without the *Tropicks* ; where it began *low*, and rose by *Degrees*, and generally was of a *small Extent* ; and consequently easily deflected out of its *Course*, by every *Bogg* and *Mole Hill* that stood in its way ; yet afforded *more Matter*, than the *Slow* and scatter'd *Obliquity* of the *Sun's Rays* were able to manage : Now, on the contrary, in the *Torrid Climate* of the *World*, where his Motion is *Swifter*, and his *Rays Perpendicular* and more *Compact* ; and the *Sunburnt Earth* neither overloads 'em with *Moisture*, nor any inequality of the *Sea* makes *Resistance* to their Operation ; his *Conduct* of the *Wind* must be *Constant* and *Universal* ; tending *Diurnally* into the *West*, and *Annually* towards the *North* and *South* ; and its Motion must be pursuant thereto, as long as the *obviating Coasts* and *Shores* will permit the *Air* to move the same way, without any *Deflection* or *Impediment* of some other Kind.

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To begin with the general *Trade-Wind*, which is most *constant* for Motion, and of *greatest* Extent : Dr. *Edmund Halley* demonstrates, that it necessarily depends on the *Diurnal Course* of the Sun ; in regard the Air, which is *less rarified* by his Heat, and consequently more *Ponderous*, must have Motion *towards* those Parts, which are *more Rarified* and *less Ponderous* (according to *Statics*,) to bring it to an *Equilibrium* : Again, the Presence of the Sun continually shifting to the *Westward* ; that part, to which the Air tends by reason of the *Rarefaction* made by his greatest *Meridian Heat*, is, with him, carried *Westward* ; and consequently, the Tendency of the *whole Body* of the lower Air is that way : Hence is formed a *general Easterly Wind* ; which being *impress'd* upon all the Air of a vast *Ocean*, the Parts impell one the other ; and so keep moving, till the next Return of the Sun ; whereby so much of the Motion as was *lost* is again *restor'd* ; and thus the *Easterly Wind* is made perpetual.

From the same Principles, Dr. *Halley* tells us it follows, that this *Easterly Wind* shou'd, on the *North Side* of the *Equator*, be to the *Northward* of the *East* ; and, in the *South Latitude*, to the *Southward* thereof ; while the Sun is *upon* or *near* the *Line* : the Air being there *more rarified* and his Motion *swifter*, than at any distance from it : Which Motions, by his Account, being superadded to the former *Easterly Wind*, answers all the *Phenomena* of the *general Trade Wind*.

Such is the *Easterly Tendency* of the *general Trade Wind* ; as also its *North* and *South-Easterly*

Inclination, on each side towards the Line; while the Sun's *Diurnal* Motion keeps near the *Equator*, as Dr. *Halley* has already demonstrated: But, before I proceed to meddle with its *shifting* Motion, as caused by the Sun's *Annual* Declination towards the *Poles*; 'tis farther requisite to take along with me his *Historical Relation* of Matter of Fact, which I strictly observe, and is as follows: *Viz.*

In the *Indian Ocean*, the Winds are partly *general*, as in the *Ethiopick Ocean*; partly *Periodical*: That is, *Half the Year* they blow one Way, and the *other Half* near upon the opposite Points; and these Points and Times of Shifting are *different*, in different parts of the *Ocean*: The *limits* of each Tract of Sea, subject to the same Change or *Monsoon*, are certainly very hard to determine: But the Diligence [*says He*] I have us'd to be rightly inform'd, and the Care I have taken therein, has, in a great Measure, surmounted that Difficulty; and I am persuaded, that the following Particulars may be rely'd on.

1. That between the *Latitudes* of 10 Degrees and 30 Degrees *South*, between *Madagascar* and *Hollandia Nova*, the *general Trade-Wind*, about *South East* and by *East*, is found to blow all the Year long, to all Intents and Purposes, after the same Manner, as in the same *Latitudes* in the *Ethiopick Sea*.

2. That the aforesaid *South-East Winds* extend to within 2 Degrees of the *Equator*, during the Months of *June*, *July*, *August*, &c. to *November*; at which time, between the *South Latitudes* of *Three* and *Ten* Degrees, being

ing near the Meridian of the *North End* of *Madagascar*, and between *Two* and *Twelve* *South Latitude*, being near *Sumatra* and *Java*, the contrary Winds from the *North West*, or between the *North* and *West*, set in and Blow for *half a Year*; viz. from the Beginning of *December* till *May*; and this *Monsoon* is observ'd as far as the *Molucca Isles*.

3. That to the *Northward* of *Three Degrees South Latitude*, over the whole *Arabian* or *Indian Sea*, and *Gulph of Bengal*, from *Sumatra* to the Coast of *Africa*, there is another *Monsoon*, blowing from *October* to *April*, upon the *North-East* Points: But in the other *Half Year*, from *April* to *October*, upon the opposite Points of *South West* and *West South West*, and that with rather more Force than the Other, accompanied with dark Rainy Weather; whereas, the *North-East* blows clear: 'Tis likewise to be Noted, that the Winds are not so constant, either in Strength or Point, in the *Gulph of Bengal*, as they are in the *Indian Sea*, where a Certain and steady Gale scarce ever fails: 'Tis also remarkable, that the *South West Winds* in those Seas are generally more Southerly on the *African Side*, more Westerly on the *Indian*.

4. That, as an Appendix to the last describ'd *Monsoon*, there is a Tract of Sea to the Southward of the *Equator*, subject to the same Changes of the Winds; viz. Near the *African Coast*, between it and the Island of *Madagascar*, or *St. Laurence*, and from thence *Northward* as far as the *Line*; wherein, from *April* to *October*, there is found a constant fresh *S. S. W. Wind*; which, as you go more Northerly,

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becomes still more and more *Westerly* ; so as to fall in with the *W. S. W. Winds*, mention'd before in those *Months* of the Year, to be certain to the *Northward* of the *Equator*.

5. What *Winds* blow in these Seas for the other *Half Year*, from *October* to *April*, [*He*] had not yet been able to obtain to his full Satisfaction ; for that our *Navigators* always return from *India* without *Madagascar*, and so are little acquainted in this Matter : The Account that has been given [*Him*] is only this ; that the *Winds* are more *Easterly* hereabouts ; and as often to the *North* of the true *East*, as to the *Southward* thereof.

S E C T. II.

Of the Shifting Trade-Winds ; and their dependence on the Sun's Zodiacal Declination, with regard to the Equinoctial Position of the Arabian Sea.

SO strictly does the mutual Concourse of the *North* and *South-Easterly* Trade-Winds observe the *Equator*, while the Sun's *Diurnal* Motion keeps close to that Line : But, when his *Annual* Declination withdraws his *vertical* Rays, and the Air grows cooler in his Absence ; the joint Occurſe of the ſaid Winds (as following close to his *greatest Meridional Heat*,) must also decline with him into the ſame *Latitude* ; whether it be to the *North* or *South* : And thoſe Winds must make their *half Yearly* Returns

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Returns of *Summer* and *Winter* alternately, on each side of the *Equator*.

Besides, the said Space of rarefied Air, still attending the Sun's *Zodiacal Declination* successively towards each of the *Tropicks*; and still intermeduating between the said *North* and *South-Easterly Winds*, must needs stagnate into Calm of so considerable a Breadth, on each side of that *shifting Line* describ'd by the Sun's *Declination*, as to hinder the said *opposite Fluxes of Air* from approaching each other at their Congress; that Geographers commonly assign it a Tract of *twelve Degrees* Tranquility: So that the Sun's *Tropical Declination* (being extended at least *twenty-three Degrees*,) more than doubly sufficeth, to draw the said *Vacuity* from one side of the Line to the other; with an *Half-Yearly Vicissitude*; as is Manifest.

Now, the *Position* of the *Arabian Gulph*, or that part of the *Indian Sea* which the said *shifting North* and *South-Easterly Winds* chiefly affect, being *Equinoctial*; it concurs very opportunely with the *Zodiacal Motion* of the Sun, either to remove 'em Alternately out of that Compass, as not exceeding *ten Degrees* on the *South* of the *Equator*, and *twelve* Degrees to the *Norward* of that Line; or at least, to abate their Force in such measure, as not to be able to resist the *South*, and *North-westerly Monsoons*; which of course succeed 'em from the Opposite Points every *Half-Year*, at their respective Seasons, to supply the *Vacuties* left behind 'em.

Hence it comes to pass, that the *North* and *South-East* Trade-Winds, never blow Both at once within the Compass of the Gulph or Sea aforesaid;

aforesaid; the One being no sooner drawn off by the Sun's Declination, than the Other is brought on again by its own Weight, to fill up the Vacuity, left on the other Side of the Equator: For so it happens in *April*, when the Sun, having pass'd the Line into the *Northern Signs*, at once carries off the *North-East Trade-Wind* from it, and draws Thither the *South-East Wind* after it; and having repass'd it again to the *Southward*, brings those Winds back again; and so carries 'em *Backward* and *Forward*; the One towards the Line, and the Other frowards it, by an *Half-Yearly Vicissitude* for ever.

It is farther observable, that those *Easterly Trade-Winds*, and *Westerly Monsoons*, which happen at the same Time, blow jointly either towards the *North* or *South*: As from *April* to *October* Both blow to the *Norward*, pursuant to the Sun's Declination into the *Northern Signs*; drawing 'em Thitherward, from a more Dense and Ponderous *Winterly* Season, into a more expanded and rarefied Air of *Summer*; and, on the contrary, They jointly, from *October* to *April*, attend in the *South* on his Presence, upon the same Occasion; so that the *Westerly Monsoons*, inasmuch as they blow *North* or *South*, are as effectually Influenced by the *Annual Course* of the Sun, as the *Easterly Trade-Winds* are to blow Hither or Thither at the same Season.

Hence it comes again to pass, that the said *South-Easterly Winds*, as Dr. Halley observes, extend from the aforesaid *Ten Degrees South-Latitude*, near the *Equator*, during the Months of *June, July, &c.* to *November*; while the Sun remains to the *Norward* of the Line to draw 'em

'em Thitherwards : And, on the contrary, that there is blowing a *North-Easterly* Wind for the other Half-Year from *November* to *June*, the Sun being on that Side of the *Line* to attract it. Now *Why*, or *How* those Two *Easterly-Winds*, so intermixing, shou'd each be supply'd for its respective *Half-Year* by a *Westerly-Monsoon* from the Opposite Point ; and to assign a Cause able to produce so constant an Effect, leaves no *Phænomena* of the shifting *Trade-Winds* Unaccounted for.

S E C T. III.

How the South and North-western Monsoons, are respectively Regulated, by the Situation and Figure of the Arabian-Sea.

HAVING shewn already (in the Former of the Two precedent Sections,) that the *South-Easterly* Wind, which blows perpetually from *Thirty* to *Ten* Degrees of the same Latitude, is drawn *Eight* Degrees nearer the Line, on the *East* Side of the *Arabian-Bay*, from *November* till *April*, by the Sun's Declination to the Norward : And in the Latter, that the *South-West Monsoon*, by virtue of his said Declination, blows to the Norward at the same time : Let us see how it acquires a *Westerly* Turn, by the Conduct of the said Bay's Situation on that Side. And it is Observable,

First,

First, That the *African Shores*, which coast the *Ocean* towards the *West*, tend *North-Easterly* from the *Cape of Good Hope* all along to the *Equator*, and beyond it to the *Bottom* of the said *Bay*; the *Land* being *High* for the most part. And *Sea-Winds*, being a *heavy Meteor*, must consequently as strictly observe their *Direction*, as *Rivers* do the *Banks* which bound 'em; and the *Winds* must follow their *Conduct* as far as they reach, especially at that *Season*, when a ponderous Load of *Winterly Air*, and *Foul Weather*, drives 'em Thitherward; with more vehemency, as *Dr. Halley* takes notice, than any other *Winds* that Trade in those *Seas*.

Besides, the said *South Ocean*, whose *Superficies* sustains that *South-West Wind* all the while, sending its *Tide* directly *Norward* towards the said *Bay*, being alike contracted on That Side by the *Inclining Shore*, the *Flux* of its *Coasting Current* must be proportionably *hasten'd*; and consequently communicate to the *superincumbent South-Westerly Monsoon*, a more fix'd and steady *Determination*, and drive its *Flux* as deep into the *Bay* as it went before.

In consequence whereto it is *Observ'd*, that a constant *Current* of the *Sea*, for all that *Tract* from *Madagascar* to the *Equator*, entering the *South-West Corner* of the *Indian Ocean*, (where the *Monsoons* first begin to shift) carries the *superincumbent Air* along with it down into the *Arabian Gulph*: And, as *Dr. Halley* affirms, a constant fresh *South-Westerly Wind* blowing along that *Coast*, on both Sides the *Line*; which, the farther you go *Northerly*,
still

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still blowing more *Westerly*, falls in (says He) with the *South-Westerly Monsoon*; or rather, gives it a beginning by falling in with it in *April*, and ending with it in *October*: which plainly demonstrates, that They *compose* and become, as it were, the *same* undiscontinued Flood of Water and Wind, conjoin'd, without any distinction; while the Sun's *Norward Declination*, at once encourages the *South-West Wind* to blow, and withdraws that *North-Easterly Wind*, which otherwise would Oppose it.

Hence it comes to pass, that the *South-West Monsoon*, as being deriv'd from the joint Current of Wind and Water aforesaid; following the *South-Westerly Direction* of the *African Shore*, which still contracts and enforceth it both by Land and Sea; and having pass'd the *Equator*, its proper Limit, penetrates to the Bottom of the *Arabian Bay*: Whereas, the *South-East Trade-Wind*, which blows at the same Time, on the *South Side* of the Line, never reacheth it, for want of the like Assistance from any *Shore* or *Current*, to help it forward: But, on the contrary, falls short of its Natural Course, at least *two* or *three Degrees*, as being repuls'd by the *contrary Motion*, of Sea and Wind; as will appear.

Now to derive the *North-West Monsoon* regularly from the same Source, or Current of Water, only *reflex'd*, which brought the other *Monsoon* directly from the *South-West*; it is to be Noted, that the Bay, wherein they are Both propagated, is of a *Triangular Figure*; the Sub-sense of whose *North Angle*, pointing directly *East* and *West*, separates the said Bay, on the
South,

South, from the wide Ocean, with a Barrier compos'd of *Isles* and *Shallows* ; whereon the said *South-Westerly* Current falling obliquely, and entring into the Gulph at its *South-West* Angle, is reflected from near the *Center* thereof, towards the other End of the said Barrier ; where the Stream refunds it again, by an *Easterly* Outward-bound Passage, into the Ocean whence it came ; drawing the incumbent *North-West Monsoon* after it from *October* to *April*, its proper Season.

Conformably to the Scheme of the *South-Westerly Flux*, and *North-Westerly Reflux* of the said Current ; Dr. *Halley* assures us that a fresh *Westerly* Wind attends it down the Bay ; which the farther you go *Northerly* still blows more *Westerly*, till they Both approach near the *Eastern* Shore ; where the Current (being now on its Return towards the Ocean) *veers* about to the *Norward*, and thence *Westerly*, till it falls in with the Conduct of the opposite *Eastern* Coast ; and follows its Direction as far as the *Maldiva Islands* ; which, tending Lineally to the same Point, steers on its Course forward *ten Degrees* farther, till it reach the *Equator*.

Now, in regard as the said Current, descending into the Bay, goes on dispersing its Stream into almost Calm Water ; so the opposite *Eastern* Shore recollects it again, and revives its Motion by the like Degrees, till it have pass'd the said *Islands* up to the Line ; where it falls in exactly with the Tendency of the *North-West Monsoon* : Hence it must needs stir up There a Motion in the incumbent Air of That Tendency ; the opposite *South-East Trade-Wind* being already withdrawn by the
Sun's

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Sun's Declination; and must carry that *Monsoon*, so rais'd, along with it, according to the same *Direction*, ten Degrees farther, being its proper Limit, till it meet with the said Wind to stop it; and the Stream underneath, having pass'd over the aforesaid Barrier of *Isles* and *Schools*, be refunded into the Ocean whence it came.

Thus both the *Westerly Monsoons* are equally beholden to the same Current: That from the *Southward*, as being carried down the *Arabian-Bay* towards the *North-East*, by its direct Course; and This from the *Norward*, as return'd back again by its *Reflux* into the *South-East*, in compliance with the Streams underneath; yet with This Difference, that whereas the Course of the Water, meeting no opposite Stream to dispute its Passage, is perpetual: On the contrary, the concomitant Fluxes of the *Westerly Monsoons*, upon the Occourse of the opposing *Trade-Winds*, alternately desist, and become *Periodical*: Those *Easterly-Winds* within their Compass, over-powering all Opposition, so as either to restrain the said contrary *Monsoons*, or set 'em at liberty; while the Sun's *South* or *North Declination*, by half-Yearly Returns, alternately sets on the said *Easterly Winds*, or takes 'em off again.

Hence it is, that the said *South-West Monsoons* begins to blow in *April*, when the Sun's Entrance into *North Signs* withdraws the opposite *North-East Trade-Wind*, which discontinues till *October*; when the Sun, by repassing the Line into *South Latitude*, brings it on again: So also the *North-West Monsoon* blows the other *Half-Year* from *October* till *April*, and then desists; with regard to the *South-East Trade-Wind*, which

riseth to countermand it : Just as *Land-Breezes*, which, following the Streams of fresh Rivers, be naturally *Perpetual* ; nevertheless they are driven back *Periodically*, by the Salt *Floods* till their *Ebbs* give 'em leave to return again, and blow *Sea-ward* as they did before.

Again, from *October* to *April*, notwithstanding the *North-East Trade-Wind* has driven back the opposite *South-West Monsoon*, from its Adhesion to the *direct* Course of the *South-West Current*, which produc'd it ; yet its Stream being *reflex'd*, and still retaining its former Force and Speed, must gradually decline the Motion of the Incumbent Air from the *Eastward* to the *Westward* of the *North* all the while ; till it has repass'd the *Line* to the *Southward*, and effectually rais'd the *North-Westerly Monsoon* ; having escap'd out of the Compass of the *North-East Wind*, which would have deflected its Course ; the *South-East Wind* being also withdrawn by the Sun's *Southerly Declination*, which otherwise wou'd have oppos'd and baffl'd it into a Calm.

Hence I conclude, That those *North* and *South-Easterly* Winds which follow the *Diurnal* Course of the Sun, never blow on *both* Sides of the *Equator* at once ; and that that *Current* of the Sea, to which I ascribe the contrary *South and North-Westerly Monsoons*, serves only, *When and Where* those *Easterly* Winds intermit, to determine the Motion of the Air that way to supply their respective *Vacuties* till their Return : And that those *Two shifting* Winds which blow at once, tend jointly either to *North* or *South* ; and still towards the Sun ; that the *Inequality* of their *Summer's* *Levity*

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and *Winter's Gravity*, may give Force and Celerity to their Motion, so as, in Substance, to be the same North and South Winds, but only differently determin'd on each Side of the Equator; *Easterly* by the Sun's Diurnal Rendance; and *Westerly* by the Current aforesaid.

SECT. IV.

How the said shifting Winds are propagated in the Gulph of Bengal, and Sea of China.

NOW, for as much as the Gulph of Bengal, and Sea of China are alike affected by the said *Western Monsoon*, and at the same Time; and all Three lye collaterally to each other, and lineally to the same Ocean, which produc'd the aforesaid Current; the Tidal Tumour thereof, to render the Cause coextensive with its Effect, must spread it self comprehensively over 'em All at once, to produce so general and Uniform a Commotion in the Air. And if that *Monsoon* be not so constant, in Strength, or Point, in the Gulph of Bengal, as it is in the Arabian Bay, 'tis because the Ocean, being contracted all along the African Shore, more immediately, and consequently more sharply, affects it; and so must needs give the Wind a more fix'd and steady Determination there, than after it is dilated by a greater Expansion.

Beside, the said Gulph being alike of a Triangular Figure, as well as the Arabian Bay; and They lying respectively in the same *Horiz-*

zonal Position; the *Tidal Motion* of the Sea, which, jointly with the aforesaid Current, falls into 'em Both with the same *Obliquity*, must equally affect 'em *directly* with a *South Westerly Monsoon*, and *Reflexedly* with a *North Westerly One*: And Both lying conjoyn'd and open towards the *South*, and *alike subtended* by the Barrier aforesaid, on that Side; the *North West Monsoon*, as being jointly directed by 'em Both, must reach coextensively along with it, from the *Eastward* of *Madagascar* to *Sumatra*; as is found by *Observation*.

But as to the *Chinese Sea*, altho' it lies on the same Side of the *Line*, and according to the same *South-West* Direction, with open Mouth towards the *Indian Ocean*, to partake of the said *South-West Monsoon*; yet its Channel more respecting the *North* and *South* Points than the Bays aforesaid do; its *Flux* of Air, as well as of Water, must needs descend the same way: But, it being withal an *Oblong* Tract of Water, and not *Triangular*; beside, being a *Thorow-fare* Passage out of one Sea into another, it can by no means reflect its Stream, either of Air or Water, back towards the *South-East* in favour of a *North-West Monsoon*; which is neither found in this Sea, nor can be reasonably expected in any other, of different *Position* or *Figure* from the Bay and Gulph aforesaid.

Now, from what I have already said of this Matter, it appears 1. That the Place so affected with the *Monsoons* must lye upon the *Equator*, or near it, to shift 'em with the Sun's *Declination*, both *Northward* and *Southward*, according

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to the different *Seasons* of the Year : Hence all *Seas*, of any other *Position*, are incapable of the like Alteration.

Besides, the *Figure* of that Part of the *Indian Ocean* which is so affected, must be *Triangular* ; with an *Inlet* at its *South-West* Angle to receive the Stream of Water which conducts the *South-West Monsoon* into the Bay ; and an *Outlet* at its *South-East* Corner, to set the *North-West Monsoon* off again by the *opposite Point* ; as appears by the special Service of every Part of the said Bay ; and how proper it is to perform its Office.

It was farther requisite, that a *Barrier*, consisting of *Isles* and *Shoals*, shou'd pass between the *South-West* and *South-East* Passages, to strengthen the aforesaid Current (which almost stagnates in the Middle of the Gulph) into a Stream, to stir up the Incumbent Air into a *North-West Monsoon* ; and withal, it was to be of a proportionable Breadth, to continue its Flux over that Rampire for Six Degrees together, into the *Southerly Ocean*, to meet the *South-East Trade Wind*, which was to stop it before it ceas'd.

And this *Barrier* was to be but of a *Mean* Stature ; neither so *High* as to hinder the Tide from passing over it ; inasmuch as it might be favourable to both the *South* and *North-West Monsoons* ; by letting the One enter the Bay as freely at the *West* End of it, as the other to go off at the *East* ; nor yet so *low* as to admit its Floods in so full a manner, as to controul or obstruct their shifting Motion.

Moreover, the *South-Western Current* of Wind, which Coasteth the *African Shore*, from near

the Isle of *Madagascar* to the *Equator* ; To which *Dr. Halley* allows a Periodical Flux from *April* to *October* ; yet terms it, not improperly, only *An Appendix* of the *South-West Monsoon*, till it hath pass'd the *Line*, tho' it be the *Origin* and sole *Cause* thereof ; in regard, till it have pass'd the *Equator*, it remains out of the *Sun's* Power to give it Check, and Return it whence it came by his *Southerly* Declination : Especially, the concomitant *South-West Current* of the Sea, perpetually resisting its Trading back again by the same Road for the other Half-Year ; to wit, from *October* to *April* ; or at least with any Periodical Constancy or certainty of Motion.

S E C T. V.

Concerning those Winds, which are Adverse to the general Easterly Winds, and are Perpetual.

TO omit Those that blow all the Year, without any considerable Variation, unless what is subject to be deflected therefrom some few Points of the Compass, towards the North or South, according to the Position of the Place ; as being, in all Respects, well accounted for by *Dr. Halley* already ; I shall only of course take farther notice of Those, which He proposeth for Exceptions to that general Rule ; in order to reconcile 'em to the Common Laws of Motion.

1. That to the Norward of the Line, between Four and Ten Degrees of Latitude, and between the

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the Meridians of *Cape Verde*, and the *Eastermost* Islands that bear that Name, *Dr. Halley* tells us, there is a Tract of Sea, wherein it were improper to say there is any *Trade-Wind*, or yet *Variable*; — the little Winds that are, be only some sudden uncertain Gulls of very little Continuance, and less Extent; — which He assigns to the *Station* which that Tract holds between Two contrary Winds; the One on its *North-side*, blowing *Easterly* from the said Cape towards *Guiana* in *America*; and the other on the *South*, from *Brasile* towards *Guinea* in *Africa*; which were more proper to turn the interjacent Air into a *Whirlwind* than to hold it steady; Did not that part of the Ocean, where the *Atlantick* and *Ethiopick* Floods meet, concur to keep it fix'd, as being obnoxious neither to *Flux* nor *Reflux* to disturb its Quiet.

2. That in the Tract of Sea, which (on the *South*) lies next adjoining to *this*, the Southerly and *South-West* Winds are perpetual; viz. all along the Coast of *Guinea* for above Five Hundred Leagues together, from *Sierra Lio-na* to the Isle of *St. Thomas*: For the *South-East* Trade-Wind, upon its Entrance into the Streight, (in compliance with the *South-West* Tendency of the Sea-Current along the *Brasilian* Shore,) becomes *South South-East*, and by degrees full *South*: And, being carried down with the Stream towards the *Guinean* Shore, veres about to *South South-West*, and by degrees to *South-West* and *West South-West*, under the close Conduct both of that Stream and Coast; till at last the Current of Water, being repuls'd by the *Eastern* Shore of *Guinea*, returns towards the *South* (whence it came) to make Restitu-

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tion : And, being ingulph'd by the *Tide's* detumescency, is carried off by *Libration* thither ; and deflects the superincumbent *Current* of Air into the *South* after all, to compleat its *Circulation*, as will be farther declared hereafter.

To these which Dr. *Halley* alledges, may be subjoin'd, as remarkable *Instances* of the same Truth,

1. That all along the *Western Coast* of *Peru*, for above *Fifteen Hundred Leagues* together, from near the *Magellanick Streight* as far as the *Gulph* of *Panama*, an uninterrupted and almost perpetual *Flux* of Air attends the *Current* of Water which supports it ; blowing from *South* to *North* ; or within a *Point* or two to the *Westward*, according to the different *Inclination* of the *Shore* : notwithstanding those *Exhalations* which compose it fall down from the *Andes* out of the *East* ; and the *Western Pacifick Ocean* lies wide open to receive 'em ; yet without giving even a beginning to an *Easterly Trade-Wind*, for all that length of *Shore* (till *Fifty Leagues* off at *Sea*;) which is perceptible.

2. That a perpetual *Flux* of Air or Wind adheres to the *Coasting Current* of the *African Shore* on the *Ethiopick Side*, from the *Cape* of *Good Hope* to near the most *Southerly Part* of *Guinea* ; which is constantly determin'd to blow *Southerly*, by the *Draught* of the *Stream* underneath ; and withal, the Wind keeps that *Flux* of Water on foot, by its constant descent from the adjacent *Shore*, so as Both to tend thitherward all the while, by the mutual assistance

of

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of each other ; with many *Instances* of the same kind, which will be produc'd more conveniently hereafter, where I profess'dly treat of the *Motion* of the *Sea* ; and shew, that the aforesaid *Coasting Currents* of the Ocean proceed from the *Tide*.

Such is the *Adhesion* of the *Incumbent Air*, to the substrate *Water*, when they are got into *Motion*, and have free liberty to follow the same *Direction* ; for otherwise each may be put to a *Stop* apart, or both be *deflected* several ways at once ; as the *South-West Monsoon*, which we spoke of before, while the *South-East Wind* was withdrawn, pass'd along the *Coast of Africk* down into the *Arabian Gulph*, jointly with the *Stream* that conducted it : And, even after the *Current* had *stagnated* in the middle of the *Bay*, as soon as it reviv'd its *Motion* towards the *South-East*, still pursu'd its *reflex'd Direction* : Yet, no sooner had the *South-Easterly Wind* put a *Stop* to its *Career*, and the *Current*, *reflected* towards the *North-West*, began to revive and gather *Strength*, but the *North-West Monsoon* did so too, and fell in with it ; and attended it thro' the *South-Easterly Passage* into the wide *Ocean*, where both ceas'd together.

By this Means, these *Sea-faring Winds* take the liberty to disorder those which Trade out of the *East*, by the Influence of the *Sun* ; in some Seas stirring 'em up too soon, and accelerating 'em above their usual speed, as near *Cape Verde* : Or contracting 'em some Degrees within their common Limit ; and by and by enlarging 'em as far beyond it ; as all along the

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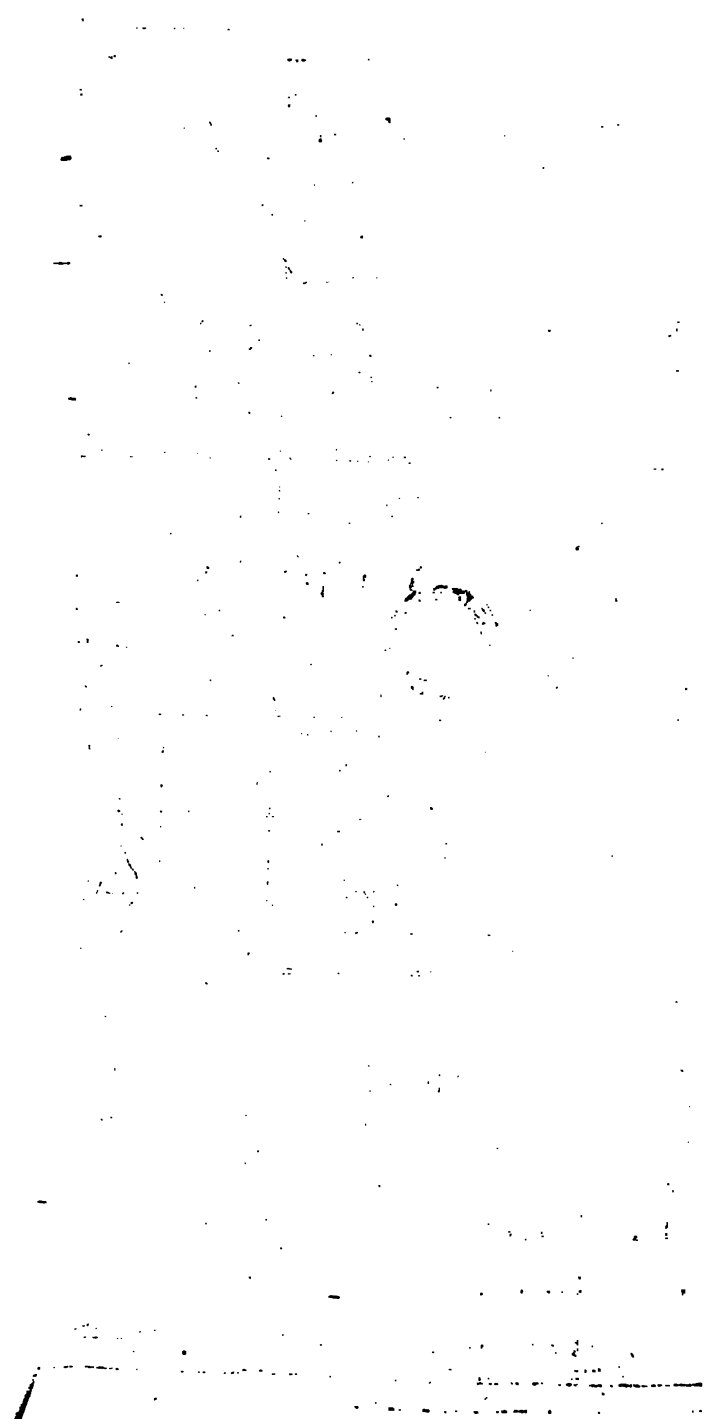
Guianean Coast : In others *thwarting* 'em as much by their *transverse* Course from *South* to *North* ; as on the *Western* Shores of *Angola* and *Peru*, for a *Thousand* Leagues together : In others, blowing directly from the *Opposite* Points, as along the *Southermost* Part of *Guinea* from *Sierra Lions* to the *Bottom* of the *Bay* ; and all this perpetually.

Yet in the *Indian Ocean*, these *Sea-bred* Gales become of so *complying* a Temper, as to yield readily to the *Periodical* Insults of its *Easterly Trade-Winds* ; and withal, as respectively to supply all the *Vacancies* left behind 'em in their *Absence* ; which answers the utmost *Enquiry* yet made into the *Phenomena* of *Winds* ; and shuts up this *last* of my *Three* Preliminary Discourses, to the finding out of the *Immediate* Causes of the various and irregular *Motion* of the *Sea* it self, which occasions 'em.

Conclusion.

TO sum up, in short, this *Tripartite* Discourse at once, in order to introduce the next of the *Motion* of the *Sea*.

First, *Springs*, as consisting of *Water*, which is *Fluid*, to pierce the Surface of the *Earth* ; and *Heavy* to sink it into its *Veins*, must Originally descend from the *Sky* ; and as it falls in Drops innumerable, so it penetrates it by as many *Holes*, which, being united underneath must gather into *Rills*, and convey'd farther still swell into *Streams* of a larger size, till they break forth into the open *Air*, either on their own



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own Accord, or let off by the Mines, without any farther Supply, than *Rain*; or other *Diversification* than their different *Descents* afford; so vain it is, to enquire after more Recruits or Managers of 'em, unless to puzzle and perplex Those, who otherwise (if put at first into the right Road of Knowledge) wou'd daily improve their Thoughts, for the good of the Publick.

Secondly, It as plainly appears that *Rain* is extracted, in invisible *Atoms*, indifferently from *Sea* and *Land*, by the Rays of the Sun; which congregate in their Fall thro' the Air, and are cast, as it were, in *Moulds* of a larger Size, into greater *Drops* of another Species upon every New Concretion; and these are again congeal'd by the *Summer's* or *Winter's* Colds into *Hail* or *Snow* of as many Sorts: But to stir up those *Atoms* of Water into *Storms* they must be rais'd to a greater *Height*: And to furnish a Quantity of 'em into *Tempests*; their Extent being large, and their Expansion evenly spread over the Firmament, and continued for a longer Season; till the Air become unable to sustain 'em, either shuffl'd together or in any other Posture.

Lastly, To convert Air into *Wind* it sufficeth to raise the grossest Part of it uppermost; and when the Sun's Heat can advance it no higher, nor sustain it longer, to let it fall again by its Preponderation; only more or less obliquely from the *Perpendicular*, as the Medium Air will allow, and the Stock 'tis furnish'd with requires: And towards that Point of the *Horizon*, that either the Course of the Sun, or the Declivity of the *Earth*, or the Motion of the

Of Trade-Winds and Monsoons.

the Sea, whereon it falls, shall farther appoint ;
 Or, in case of their *Indifferency*, the Poise of
 its own Weight *pressing* downwards, and the
resistance of the Air, growing still more *obstinate*
 by Oppression, makes it wheel about *circularly*
 for the easiest Descent into *Whirlwinds* or
Hurricanes ; from the *Weight* of the Matter, and
 the *Height* of its Fall ; as is manifest.

T H E



THE
Second Treatise.
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OR THE
EBBING *and* FLOWING
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WHEREIN,

All its various Appearances
are Clear'd, and Difficul-
ties Solv'd.



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P R E F A C E.

HAVING already adjusted, and settled the Preliminaries of Springs, Rain, and Wind; as to their Origin, Generation, and Production; I am now to treat of the Motion of the Sea in General, before I can branch it into Particulars, in search after the immediate Causes of the Tide: And not to embroil the Matter in Hand with unnecessary Disputes, a Method is to be propos'd and follow'd; and that which I have actually pitch'd on, being either not usual, or pursued farther than ordinary, I shall here unfold it before I begin; and at every Step, annex Reasons for my proceeding after such manner; that the Reader may never lose himself in following it, or be out of his Way.

First, In regard the Sea is subject to another sort of Motion, I shew, (for Distinction's sake) that, whereas that other tends always Westward; this, of the Tide, Flows and Ebbs reciprocally North and South; that is continual; this Periodical, that depends on the Trade-wind, this on the Course of the Sun, and Moon; and that having been discours'd on already, (when we treated the Monsoons) as to the variety of its Declination towards North and South, becoming of a quicker Dispatch, I first remove it out of the way; that,

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PREFACE.

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when it chanceth to interfere in our following Discourse, with the Motion of the Tide, it may be easily distinguish'd from it, in some of those Respects, to prevent Confusion.

Secondly, Whereas the Tide is liable to many Disorders, occasion'd by the irregular Situation of Coasts, and Shores: To prevent the framing of a wrong Notion thereof, on that Account, I abstract from all such Restraint throughout my First Chapter; by supposing our Globe to be surrond'd around with Water, without End, or Limit; to give free Liberty for the Moon, to raise Two Opposite Tides daily, with One Revolution; and the Sun, to increase 'em twice monthly; and both jointly, to raise 'em higher than ordinary, as many times every Year.

Thirdly, Since the Universal Ocean is actually divided into Three Parts; and these are separated by great Tracts of Land; and the Indian, and Pacifick Oceans, are less known to Us, than Our, which consists of the Atlantick and Ethiopick Seas conjoin'd, and reacheth the Artick and Antartick Circles; to allow the Tidal Flood its full Range either way, from the Equator, whence it is rais'd: Hereupon, I undertake to speak professedly of the Phenomena of the Tide in this Ocean, and only by the By of those which belong to the other Two: Again, as to the Diffusion of its Flood on each side of the Line, I chiefly endeavour to analyse that Part of it which transfuseth it self over our North Atlantick Division, with the greater variety of Appearances, and lies more immediately under our Inspection.

Fourthly, After the Arrival of the Tide at the European Coasts; and it has enter'd our Irish and British Channels; I trace it around both Islands, and pursue it to every Port, and follow it up the Rivers,

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Rivers, as far as they are Navigable; denoting all along the Time, and Place of their Floods, with such Diversity of their Phenomena, as seems to abridge all kind of Appearances, that can possibly happen elsewhere, throughout the Universe: And to assure the Reader, that all whatsoever may be answer'd on the same Grounds; I have industriously pick'd up those which seem'd most odd and intricate, and brought 'em to the Test of a due Examine, and found 'em at the Bottom conformable to the same Principles.

Fifthly, For Illustration's sake, I have drawn a Map of the Course of the Tide, according to the Common Tide-Tables, for all that Compass; to expose to the Eye, the Order and Progress of 'em all, at one View; for an Example, how to perform the like of the Tidings in all other Seas, which doubtless will be executed in Process of Time; as being no less Useful, than Satisfactory to the Curiosity of Mankind, tho' as yet never attempted: Those, who drew not the Origin of 'em from the Equator, not knowing where to begin their Work; and those who did that, apprehending as little how to end it; Especially, being all the while involv'd in that vulgar Error; viz. That it made High-water upon the First Meridian, both here and there, at the same Instant.


Thus far I argue, from the Cause to the Effect; viz. That the Moon's Pressure upon our Atmosphere, makes the like Impression upon the Sea underneath it: Again, that the Depression at the Equator (after the same manner) raiseth correspondent Tides between the Tropicks and the Polar Circles: Then, that the Tumour in the Atlantick transfuseth it self on the Coasts of Europe, &c. And entring our British, &c. Channels, fluctuates

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fluctuates up in the adjoining Rivers, still arguing from Universals to Particulars; yet, supposing all the while, the Consequence to hold on the Converse; viz. That if her Pressure be the Cause of the Tide in Thames, for Example, it truly causeth it (for their strict Connexion, and free Communication,) in all the Rivers, and Seas, throughout the World: So that what I here suggest, is not imperfect in its kind; but only requires a farther Application to all the rest.

Lastly, It is in vain (on the Negative Part) to search out other Causes, to interpose between her Pressure and the Sea, to obstruct its Operation; or in the least to interfere with it, as a Partner in the Tide's Production; or to act consistently with it, by any other Means, than (as the Sun does) by way of Pressure, without acting Counter to it; as the Moon her self would do, in case her Plenilunary Light rais'd the Tide by Fermentation, while her Corporal Presence depress'd it at the same Time; and the Sun wou'd do the like, if at once he Rarified and Attracted the Flood by his Heat, and condens'd and protruded it into an Ebb, in the same Place: And as for the Motion of the Earth, or the Influence of Planetary Bodies, being concern'd in the Work; they are demonstrated, after all, to be neither proper nor seasonable to effect any such thing. Now to my Task.

Second



Second TREATISE

Of the Tide ; or the Ebbing and
Flowing of the Sea.

CHAP. I.

*Of the Ocean's continual Flux into the West ;
and of the Cause of the Tide, and how it
is effected, according to its full Extent.*

SINCE the Motion of the Sea
in general is divided, 1. Into a
Westerly one, whose Flux is
Perpetual ; and, 2. That of the
Tide, which is Periodical, and
still Ebbs and Flows recipro-
cally North and South : Now, pursuant to the
Account I have already given of the Produ-
ction of the Wind, in the precedent Chapter, I
am to proceed in this, (of the Motion of the
Sea) to demonstrate what Influence the Wind
has actually upon the former, with regard to
its continual Devolution into the West, as a

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necessary Preliminary, before I enter upon the Motion of the *Tide*, which consists of a constant *Reciprocation*, Back and Forwards, between the *Equator* and the *Poles*; to shew, whether they have any more *Dependance* on one another, than what is meerly *Accidental*; and that the *Tendence* of the Former may perhaps, in some *Circumstances*, interfere with the *Course* of the Latter.

S E C T. I.

Of the continual Flux of the Ocean from East to West, caused by the Wind; and that its different Motion from the Tide, neither concurs with it, nor obstructs it, as to the Substance of its Motion.

FIRST, Both Reason and Experience evince, that *Wind* and *Water*, being heavy and liquid Bodies, the one floating upon the Surface of the other, they must, throughout the *Ocean*, be every where very *Contiguous*; and, by Consequence, in some measure *Coherent*, and very loath to be parted: Hence it is, that the *Wind* inclines the *Sea*, in Compliance with its Motion, to retard or hasten its *Tides* into our *Rivers*; and the *Ocean* never suffers any *Tumultuous* Disturbance within it self, without *Storms* of *Wind*, and *Tempests* of *Weather* in the *Air* to raise it.

Now, in regard the *Trade-Wind*, as directed by the *Course* of the *Sun*, blows continually *Westward*, and wafes over the largest *Compass*

of the Earth; it must needs drive the Surface of the Ocean, between the Tropicks, the same way: Hence the Mariner, in his East-India Voyages, which lie mostly within the Compass of that Climate, is forc'd to quarter the Course of the Sea, as well as the Wind, to get thither; and at his Return, he makes the best of his way, both being favourable; or else his Arrival in Europe would be so late, as to miss his Market.

Besides, That vast Body of Salt-water, whereof the Ocean is compos'd, being Ponderous as well as Self-coherent, must needs be slow in receiving the Motion of the Wind, and as loath to part with it; and consequently, the farther its Course is continued towards the West, the more it must be increased, at least to a determinate Height: Hence the Mariner well observes, that the Mean Course of his Ship is heightned in the same Proportion; sailing from Europe to America in a much shorter Time than he can make his Return; and his Voyage from the East-Indies to Brasile spends scarce half the Time that it does back again; but he passeth from Peru to China, thro' the Pacifick, (where that Wilderness of Water has free Liberty to rowl before the Wind) Three Thousand Leagues in Eighty Days, with much less Use either of Sail or Oar, than is customary in other Seas.

And, forasmuch as the continual Flux of the Ocean into the West, still raiseth a Protuberance on the Sea's Superficies, before the Wind; which is continued, as far as the Ocean lies open that way, to receive it; its Surface must all along be proportionably advanced, and the

longest Course must raise it to the *highest* Pitch: Hence it is, that the Flux of the *Atlantick*, from the *African* Coast to the Bottom of the *Bay of Mexico*, makes such Haste thro' the *Caribbees*; and the *Pacifick* does the like, from the back side of *Peru* thro' the *Anian Gulph*: But the Course of the Ocean, from the *Pacifick*, along the *Indian Sea*, towards the *Magellanicke Streights*, being the *farthest* Drift, pours down the *strongest* Stream, and with the *greatest* Precipitation that can be found elsewhere, as falling from the *greatest* Descent. And since the Protuberant Flood before the Wind must needs leave as deep an Ebb behind it, yet cannot possibly return back exactly the same way, to supply that Vacuity; that Protuberance must force a Passage back again underneath itself, by the Preponderation of its own Weight, to devolve its Stream into the East, and reduce, in some measure, the Surface of the Sea into its Natural Posture, by an alternate Revolution; still rising higher on the one Part, and returning faster towards the other; the general Surface of the Ocean mooving all the while higher towards the West, especially between the Tropicks, where the Wind and the Sea keep better Touch with one another. Such is the Motion of Undulation, that, (to preserve the Water's common Level) how much soever it is raised above it, by Result from any Depression; and is waved forward by Protrusion, it is as constantly devolv'd back again underneath, by way of Restitution. And for want of this Return, after Marten-Mere in Lancashire, was drained to a few Inches deep; its Bottom being

being near a Water-Level, a Gust of Wind, in *one Night's* space, drove *twelve Hundred*; *Airs* of it to a New Ground; as having not, a competent Depth of Water, to devolve it; self *back again* at the same Time; and there it remain'd, till the Wind ceasing gave it liberty, to return whence it came.

Yet, in regard the Sun spreads the Influence of his Rays beyond the Limits of the *Torrid Zone*, at once, over the whole Extent of the *Hemisphere*; the depending Wind must, to some degree, affect the *Sea* with a Motion, as universal; that is, from the one *Pole* to the other: Whence it is found by Experience, that wherever there lies a *Passage* open *Westward*, out of one part of the *Ocean* into another; the *Current* still holds on its *Western* Course thro' it, without any return; as appears, by the Course of the *Magellanick Gulp*, which flows constantly out of the *Atlantick* into the *Pacifick Ocean*; and the *Pacifick* runs again *Westward*, thro' the *Anian Straights*, towards the *Arctic*, the one near the *Arctic*, and the other near the *Antarctic Circle*; both running *Westward*. This Flux of the *Ocean* holds on universally *Westward* in every free and open *Sea*, where the Declivity of some *transverse* Shore deflects, not its Course any other way; as it manifestly does in our *North-Part* of the *Atlantick*; whose *South-west Coast* of *Guiana*, from the *Mouth* of the *Amazons*, declineth above *Thirty Degrees* of *North-Latitude*, before it reach the Bottom of the *Bay of Mexico*. And the Flux of the *Ocean* bearing up against it all along from the *Coast of Africk*, passeth in a Crowd thro' the

Caribees, North-west; and is reflected from the Bottom of the Bay *North-East* thro' the *Antilla's* with the same Violence and Precipitation, till it transfuseth and loseth it self in the vast Expansion of the Ocean whence it was first rais'd, to re-furnish it again with its *Quota* of Water, and compleat its Circulation: an Expedient which turns doubly to the *Mariner's Account*, to fall down by the *South-Current*, from the Latitude of the *Canaries* into our *Western Plantations*; and when he is *Homeward-bound*, the *North Channel* serves as well for his speedy return Thither.

And for an Experimental Evidence, that such a Contrariety of Motions is compossible in the Ocean, we have 'em All compriz'd within the narrow compass of the *Bosphorus*; which has alike *Two contrary Currents*, one on the *East Side* from *South* to *North*; and another on the *West* from *North* to *South*; according to the different Direction of the opposite Shores; so that rowing over the Channel, you are either carried out of the *Euxine* into the *Propontis*, or back again, while the *Middle Stream* runs both ways at once; the *Upper Six Foot* of its Current (which riseth out of the *Euxine*) sliding over the *Lower Part* of its Stream from the *Propontis*, which forceth its way back again all the while underneath; the *Fresher and Lighter Water* of the *Euxine Sea* floating upon the Top, while the *Salter and Heavier* of the *Aegean* sinks to the Bottom.

Such Variety of Fluxes, To and Fro, and Up and Down, with their Circulation, and all of the same Nature, and arising from the same Cause,

Cause, being experimentally *compossible* and *Practicable*, within the small compass of so *Narrow* and *Shallow* a *Gullet*; what can be objected against the above-said *Western Flux* of the *Ocean*, and that *North* and *Southern* one of the *Tide* (being *Motions* of *different Natures*, and proceeding from *several Causes independent* on one another,) taking their full range in the vast *Extent* of the *Ocean*, without interfering? but that they are necessary *Truths*, and *Geometrically evident*, so as not to be question'd.

The *Former*, proceeding *Originally* from the *Sun's Heat* rarifying the *Air*, and driving its *Flood* into the *West*; and the *Latter* being rais'd by the *Pressure* of the *Moon*, and tosd from the *Equator* towards *North* and *South*, and back again alternately: *That* floating upon the *Surface* of the *Sea* all the while; *This* diving down into the *Deep*, and rising up again by *Undulation*; *That* constantly affecting the same *Place*, and always alike; *This* being *Periodical*, and making its *Visits* here and there with endless *variety*, &c. as I have already shewn of the *Former* in this *Section*; and shall do the like of the *Latter*, occasionally by degrees, throughout the following *Discourse* upon that *Subject*.

Notwithstanding, since we find by *Experience*, that *Winds* of other *Sorts* sometimes *hasten* or *retard* the *Motion* of the *Tide*; sometimes *swell* it to an extraordinary *Height*, or *rebat* it as much; and sometimes drive it with more violence against one *Shore* than another, with an endless *variety*: We must needs acknowledge, that the *Trade-Wind*, which has a more even and constant *Motion* than the

Rest, *Westward*, sometimes deflects the Course of the Tide from its true North and South Declination from the Equator some Points *Westerly*; yet without sharing in the Causality of its Substance, or being an Impediment to its proper Motion more than by Accident, or by way of a Modification to its Effect.

Just as a Stone cast into a standing Pool, raiseth an Undulation perfectly Circular, which the Stream of a River wou'd have formed into an Oval Figure, by sharp'ning it before into an Hyperbole, and blunting it behind into an Ellipsis, and compressing it on each Side Parabolically; rendring the whole Figure an imperfect Compound of all the Curvilinear Conic Sections, yet without being even a Partial Cause of the Undulation in itself; so the Trade-Wind, and the Course of the Ocean pursuant thereto, barely Modifies the Tide as to its extreme Parts; inasmuch as it affects the Shores, and floats upon the Surface of the Water, without exercising any Causality upon the Substance of its Motion, which dives underneath it.

As to the Direction of the Tide, it is determined by the Force of the Earth, and shall be shewn in the next Section; and shall be shewn in the next Section, occasionally by degrees, throughout the following Discourse upon that Subject.

Notwithstanding, since we find by Experience, that Wind or other Sorts sometimes do alter or retard the Motion of the Tide; sometimes swell it to an extraordinary Height, or raise it as much; and sometimes drive it with more violence against one Shore than another, with an endless variety: We must needs conclude, that the Trade-Wind, which has more even and constant Motion than the Rest

SECT.

S E C T. II.

That the Tide is caused by the Moon's Pressure upon our Atmosphere; and how it is effected.

TO disclose the true Cause of the Ebbing and Flowing of the Sea, as contradistinct from the Flux and Reflux found in those Rivers which have an immediate Communication with it, and cannot be discover'd out of their Precincts; at least the Motion of Undulation must needs be admitted in the Ocean it self; for as much as the Flux of the Sea necessarily descends from a higher Station; and the Reflux back again returns to a Lower than those Rivers which they affect; and by consequence, the Surface of the Sea must respectively rise and fall from the one extream to the other: Now, in regard the Sea is a Ponderous and Inanimate Body, the Motion of Ascent and Descent, which is merely Local, must be forced upon it by some Exterior Agent, while its own Innate Propension to a mean Situation, still endeavours to re-settle It in its Natural Posture, which produceth that Alternate Vicissitude of Reciprocation, which affects the Tide.

First, To assign the said Mean, its proper Situation: For as much as Salt-Water is a heavy Element, and of a liquid Constitution, its Superficies must naturally sink all over to an exact Level, and keep its extreme Parts to an equal Height. Again, in regard the Earth and Sea conjoin'd compose one Terraqueous Globe; and

and consequently respect one and the same Point for the Center of their Gravity ; the superficial Level of the Water cannot be Flat or Plain, but Curv'd or Spherical, to keep its extreme Parts equidistant from it, and hold its Libration on all Sides in an even Poise : Hence it follows, that whensoever any Depression is made in one Place, it must raise as high, or at least an Equivalent, Rebound in another ; and both must be finally reduc'd to a Water-Level, by the innate propension of its Gravity ; and that so constantly and necessarily, that to advance any permanent Protuberance upon the Ocean's Surface, is so gross and groundless an Error, as not to deserve the regard of a farther Refutation.

Hence it follows, that the Motion of the Tide may be caus'd alike by *Alleviation* or *Depression* ; for whether the Surface of the Sea be Alleviated or Depres'd from its Natural Level ; it must, by the Laws of *Restitution*, return back again thither with the same Force and Speed ; and repeat its *Undulations* to the same Height and Depth ; and both ways they must return back to their Natural Level, at the same Rate, whether they be rais'd by *Alleviation*, or else by *Rebound*.

But, in regard *Depression* proceeds immediately and necessarily from the meer Application of some other Body to the Superficies of the Sea ; the Pressure of the Moon, v. g. must be admitted for the Cause of the Tide, and is to be pursued, as far as it will go before we have recourse to the Sun's Rarefaction, Magnetick Attraction, Inexplicable Influence, Occult Quality, or Motion of the Earth ; whose Existence is either

Flux and Reflux or Tide.

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ther questionable, or Co-operation uncertain; and consequently, not to be admitted without the utmost Assurance of Reason and Experience. Hence,

Secondly, Touching the *Exterior Agent*, which acts by Pressure upon the Sea's Superficies, and raiseth it contrary to the *Natural Propension* of its own Gravity; the ambient Air, or our Atmosphere, first occurs to be accepted; as being *Contiguous* and *Co-extensive* both to Land and Sea; and *equivalent* in Weight to *Thirty Inches* of Quick-silver in the *Barometer*; or to so many *Foot* of Water; and, by consequence, wou'd much more than suffice to make the *Tidal Impression*; but by depressing the Ocean every where at once, and in all Places much alike; it rather keeps its Surface *Steady* in its Natural Posture, than drives it into any Disorder.

And, to ascend to the *Higher*, and more *Ethereal Region* of the Air, which is immediately *continuous* with the *Lower*; it cannot depress the Atmosphere more Intensely in one Place than in another, as being *equally co-extended* to all Places at once, and every where *Equilibrates* in it self; and so cannot make any *Inequality* in the Surface of the Sea underneath, by its own *Intrinsic Power*, which is so *indifferent* to all Places, that it cannot particularly affect any one more intently than the Rest, within the same Hemisphere.

However, this *Ethereal Space* of the Air, consisting of Matter as well as Form; and being a substantial Body, endowed with all its Three Dimensions, *Length, Breadth, and Thickness,*

ness, purposely to take up room ; how *Thin* and *Subtle* soever it be, it must be *Condensable* by a constipation of its Parts ; and *Elastick* by their Relaxation ; and consequently capable of receiving *such Impressions*, from any Superior *Planetary Bodies* passing over it, and of *transmitting* 'em into the subjacent *Air* or *Atmosphere* below ; to be derived to the Surface of the *Sea* underneath ; as also of having 'em *taken off* again *Periodically*, to cause that *Ebbing* and *Flowing* in it which is called the *Tide*.

Now, in regard the *Moon* moves in the *lowest* Sphere of all *Planetary Bodies* ; and her Motion is *Concentrical* to our *Globe* of *Earth* and *Sea* conjoin'd ; and so at her *Nadir*, she is *farther* distant from any determinate Place thereon by a whole *Diameter* of the *Earth* ; and as her *rising* upon the *Horizon*, she still remains distant from the same more than *half* so much, than after she is arrived to its *vertical Point*. And again, the *Lines* of her *Pressure* where they are *shortest*, they become most *direct* and compact, to make the *deepest* *Impression* upon the *Aether* ; and by its *Mediation* upon our *Atmosphere* ; and this also upon the *Sea* itself ; and by parity of Reason, must be continued *around* the *Universe*, from *one Meridian Westward* to another, correspondently to her *Diurnal Course* ; and be still repeated at her return to the same *Point* indefinitely without intermission : So must the *Tide* do also.

Besides, the *Approximation* of her *Orb* to the *Sea* gives her power to act upon it with a *great* *Energy*, more than all the other *Celestial Bodies* which lye scatter'd over the *Heavens* at a *far greater* distance from it ; without any *spe-*
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cial Determination to the said Effect : And the Interposition of *her* Sphere, between the *Sea* and *theirs*, must needs obstruct their Influence upon the *Tide* as much : So that the Motion thereof little regards any other Influence beside *Hers* ; as we find by daily Observation, and shall be fully demonstrated hereafter.

Thus, on the one Part, as the Pressure of the *Moon* is the most proper and effectual Cause, to produce the said Effect ; so the *Ocean* is the best disposed Subject possible to receive it ; as maintaining its Spherical and Natural Level purely by the Equilibrium of its Surface, which is manifestly taken away by the *Moon's* Pressure : as being still reciprocally enforced upon it in one Place, as it is abated in another ; the Element of Water (the Matter whereof it consists) being render'd indefinitely voluble by the Extent of its Superficies, and the profundity of its Depth : So that, in regard neither the Cause wants Power ; nor the Medium due Application ; nor the Subject a fit disposition for the Effect ; that it shou'd not follow is absolutely impossible.

So manifest it is, That the vast Body of the *Moon* cannot be hurried from our Nadir up to our Horizon, and from thence to our Zenith ; and be posted down again into the West, and return'd to the Place whence it came, in Twenty-Four Hours space, without raising as vast a Commotion in the Medium thro' which it passeth : And that she shou'd be so nearly obtruded upon Us, and snatch'd away again from our Hemisphere to so vast a Distance, and with so great Dislocation of the Parts of the Medium, as to make room for her Reception, and fill it up again at every Instant ; yet, that this Turmoil

moil should not cause the *Tidal Alteration* on the *Sea's Superficies* underneath, is another *Impossibility*.

Hence the Motion of the *Tide*, pursuant to her *Pressure*, does not barely correspond thereto, as the *Thing* signified to the *Sign* which represents it; but necessarily depends upon it, as the true and real *Effect* doth upon its proper *Cause*; that is to say, at all *Times* and in every *Place*, according to the manifold *diversity* of her Motion; as is found by *Observation*: And, forasmuch as the *Periodical Increase and Decrease* of its *Floods and Ebbs*, exceed the more constant Energy of her *Pressure*, both by way of *Excess and Defect*; the Difference ariseth still from another Sort of *Pressure*, interfering with *Hers*, without recourse to any other kind of *Causality*, which wou'd be either proper or possible to give her any Assistance towards the performance of her Work, either as to the *Whole* or any *Part* of it; as will appear hereafter: Now, to shew how well qualify'd her *Pressure* is to produce the *Tide*, as to its *Substance*; or, inasmuch as it consists in a *Mean*, between the Two *Extreams* aforesaid; 'tis my present Task to explain it more fully in the next *Section*.

S E C T. III.

The Efficacy of the Moon's Pressure upon the Sea for the Tide's production; and its several Qualifications for that purpose.

TO put the Sea in its best disposition to receive the Effect of the Moon's Pressure; suppose her first Impulse finds the Surface of the Sea exactly smooth, and profoundly quiet; its Extreme Parts standing throughout in an Equilibrium, it is in the readiest Disposition to be sunk below its Spherical Level; and in the easiest Posture to rise again above it (as a Pendulum is best disposed for Motion To and Fro, when it hangs perpendicularly;) and by the first Impulse it is better prepar'd to receive a Second; which, being regularly apply'd sinks the Sea's Superficies lower; and gives it an Additional Force to spring it self up again Higher than before: And so upon her third Impulse, its Ascent and Descent still increase in a Progressive Proportion; till the Active Force of the Moon's Pressure, and the Passive Resistance of the Sea's Superficies arrive to an Equality; and then their Progress is at a stand: Just as a Pendulum, mov'd by Clock-work, requires the helping Hand of the Artificer to set it on foot; and after that, it continues to raise its Vibrations higher and higher, till their Motion becomes at last equal and constant; and so continues ever after.

Next,

Next, the *Ether*, which intervenes between the *Moon* and the *Sea*, being a Corporeal Substance, of how *thick* and rare a Constitution soever; yet it must grow denser and harder by Compression; not only to transmit her Pressure upon the *Sea*, but also to enforce it downwards, thro' all that space; and the quicker the Impulse is, the deeper Impression it must make. Hence, the great Celerity of the *Moon's* Progress, from her Uprise in the *East* till she reach the *Meridian*, must drive all the while her Impulse more forcibly to the Head, in that gross and dull Element of *Water*: As *Fire*, so rare a Substance as it is, dislodged out of the Mouth of a *Canon*, by the excess of its Celerity, makes a violent and irresistible Concussion in the much denser *Air*. In like manner, the *Ether*, tho' it be rare and light in itself, yet, by the *Moon's* Impulse, may make a deep Depression on the Surface of the *Sea*; as well as the *Air*, tho' it be a Hundred Times lighter than *Water*, preponderates *Quicksilver* in the *Barometer*, which is twelve times heavier than it, in proportion to the Poise of its own Weight, conjoin'd with the Multitude of *Vapours* and *Exhalations*, which it sustains.

Besides, the vast Depth of the *Ocean*, by stooping its Bottom so low, renders the great Body of *Water*, which it sustains, more volatile, and better disposed for Depression: As its proportionate Length and Breadth, by disjoining the *Shores*, affords its *Middle Stream* an equal Liberty to expatriate it self more freely every way. Again, whereas those *Shores* and *Bottoms* are fix'd and steadfast by Nature; and the *Water* contain'd within their Compass is

moveable,

moveable, and cleaves close to 'em on all Sides; the *Points* of their Adhesion serve as *Centers*, for the *Lines* of Water (which are loose at the other End) to turn upon 'em, as so many *Radians*'s upon their *Axes*, which the farther they are extended the faster they move, and the easier they are set on foot. Hence it comes to pass, that the Broader and Deeper the Ocean is the easier it must submit; and the Lower it must stoop its Surface to the Pressure of the Moon; and still Lower beyond comparison than in our *Narrow* and *Shallow* Seas, as is found by Observation.

Again, as to the vast *Extent* of her Influence: Her *Lines* of Pressure (no less than the Beams of her Light), are poured down, *Hemispherically*, upon the whole Superficies of the Ocean at once, which makes their Impression both strong and comprehensive, as being the Adequate Effect of so universal a Cause; and must co-extensively affect all the Seas and Tides on one half of the Globe at the same time, and powerfully too, by their direct Impulse; as well as the Beams of the Sun, reflected universally from the Earth's Superficies, suffice to raise so great a Quantity of Water into the Air, in one Day's space, as wou'd suffice to furnish all the Rivers in the World (according to their ordinary Course) with a Week's Expence of their constant Stream: Yet, forasmuch as general Causes are not apt to produce particular Effects without some special Determination; and since the Ocean's Surface cannot possibly be rais'd or depress'd in all Places at once; the said Pressure must differently affect 'em. Hence (on the contrary) in the Production of the Tide,

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Finally,

Finally To determine this smart and universal Pressure, to affect *some one Place* of the Sea more effectually than the rest; it is farther to be consider'd, that the *Earth* and the *Moon* being alike of a *Globose Figure*, and consequently of a *Convex Superficies*; the *Lines* of Pressure, sent down from the Body of the one, must fall upon the Surface of the other at *all Angles*: But those that fall *perpendicularly*, as being the most *direct* and *compact*, give the *smartest Strokes*, and make the *deepest Impressions* wheresoever they light; whereas, the rest which decline from 'em, growing more *Oblique* and rarely *Dispers'd*, suffer a Tumour to rise *circularly* about the Point depress'd; which, if she be at her *Equinox*, must fall *perpendicularly* upon the *Equator*: And, in regard the Moon is *continually* in Motion towards the *West*, the said Point depress'd must follow her in the *same Tract*; and lineally describe the *Equator* it self (as following its direction) *Westward*: And since every Lineal Depression must raise a *correspondent Tumour* on each Side thereof; the *Undulations* so raised must lye extended from *East to West*, in *Lines parallel* to the *Equator*; tho' they move To and Fro, with regard to *North* and *South*.

After all, those Two Waves, swelling up *collaterally* on each side of that *Equinoctial Depression*, and having *free liberty* to rowl respectively towards the *North* and *South Poles*, must still raise and dilate their *Undulations* both Ways at once, as long as the Pressure *increaseth*; and upon its *Relaxation* they are to fall back again into the *Vacuity* left behind 'em, and finally

upon the *Equator* ; and their Motion having acquir'd its *utmost Celerity* by their Descent, cannot stop in their Congress, but must proceed to remount one joint *Undulation*, at least to an equal Height with those Two which rais'd it forwards the *Poles* ; as being the *Counterpoise* of their *Libration*.

So easy is the Element of Water to be wrought upon, and so ready and well dispos'd by the *Spherical* Situation of the *Ocean's Surface*, to receive any *Impression* from an Exterior Agent : And withal, so powerful are the Advantages wherewith the *Moon's Pressure* is furnish'd to operate upon it : And so *Connatural* is the Manner of their Operation to the Production of the described Effect, that it cannot chuse but follow accordingly.

Or, on the contrary, to suppose that *Column* of the intervening *Aether*, whose *Diameter* is equal to that of the *Moon's Orb*, and its *Base* as large as the *Planisphere of the Earth*, shou'd be contracted in Length, by her *Pressure* upon our *Globe*, its full *Semidiameter* in Six Hours space ; nay, be pitch'd upon our *Hemisphere* and taken off again in Six more ; yet the *Sea's Superficies*, which sustains a proportionable share of the Burthen all the while, shou'd neither be depress'd by the *Application*, nor alleviated by its *Removal* ; nor suffer any *Impression* from its Impulse, so harden'd by its *Vicinity*, and sharpen'd by the *Moon's* and the *Ocean's Convexity*, (as it were on purpose to make it ;) That, (I say) the Element of Water, so easy to be wrought upon, and its Surface in the most yielding Posture of its *Equilibrium*, and of so vast an *Extent*, shou'd, notwithstanding,

refuse to *resent* the Energy of her Operation, in so advantageous Circumstances ; implies, that either the whole *interjacent Space*, that discriminates her *Atmosphere* from ours, is a *meer Vacuity*, and contains *Nothing* at all in it, destructive to the Complex *Constitution* of the *Universe* : Or, that a *powerful Cause*, duly apply'd to a *well-disposed Subject*, shou'd not *actually* produce its proper Effect : which includes a *Contradiction*, and is *impossible*. But this Point being gain'd, as to the *Substance* of our design'd Effect ; let us try what *farther Advance* can be made for its daily *Increase*, from the *Constancy* and *Regularity* of its Cause's Application : Yet, nevertheless, the *following Rub* remains to be remov'd out of the Way.

Objection from the Weather-Glass Solv'd.

TO lessen the Force of the *Moon's Pressure* upon the Ocean, it is *objected* that *Quicksilver*, tho' it be rais'd in the *Barometer* above *Thirty Inches*, by the *Weight* of the *Atmosphere* ; yet it is not sensibly advanc'd any *higher* in the Tube, by the supposed *Additional Pressure* of the *Moon* : And, whereas the *Tide* riseth not *Five Foot* at one season, and at another exceeds *Fifty* ; the *Quicksilver* takes not the least notice of any *Variation* ; which seems to evince, that either it is not rais'd by *Pressure* ; or the *Quicksilver* in the *Barometer*, wou'd make us *sensible* of the Operation.

To

To remove this Rub out of our way, on the one Part ; *viz.* That the Quicksilver is not rais'd by the *Moon's Pressure* : the Mineral is *twelve* times heavier than Water ; and, by consequence so much harder to be rais'd : *Again*, it exceeds Water no less in *Consistence* than in *Gravity*, and so must be *Twenty-Four Times* less voluble, by way of *Undulation* : Moreover, it grows much harder to be moved within the strict confinement of a *Tube*, of no more than the *Fifth Part* of an *Inch* Diameter : Besides the close *Adhesion* it has to it on all Sides at once ; as appears by the protuberance of the *Blebb* in the Middle, while it riseth ; and the *Cavity* of the Depression, when it falls again ; yet all those *Reluctances* are jointly to be overcome at the same Instant, whensoever it is rais'd.

Whereas, on the contrary, besides the *Levity* of the Water it self, it is, in respect of the *Ocean's vast Extent* in Length, Breadth, and Depth, indefinitely *Fluid* ; and so, is easily rais'd by *Pressure*, and mov'd no less effectually by *Undulation* ; as Streams, the *broad*er and *deeper* they are, still they become *easier* and *swifter* in Motion. Hence, the *first* Impulse of the Moon, having made any sensible Impression upon the Sea's Superficies, that *first* Commotion is rais'd considerably higher by a *second* ; and this by a *third* ; and so *progressively* ; still superadding to the *reciprocal Libration* of the *Undulations* ; while the Active Power of the one, and the Passive Resistance of the other come to an *Equilibrium* ; which finds no Place in the Motion of the Quicksilver in the *Barometer*, for want of its *first* Effect ; the leading

Pulse being quite *lost*, which shou'd occasion both the Birth and Growth of all the rest.

Hence it is no wonder, that neither the Pressure of the *Moon* shou'd give any visible Rise to the *Quicksilver*; nor the Weight of the *Atmosphere* breed any sensible Commotion in the *Sea*: For, altho' both act by *Pressure*, and very effectually too, when they are duly apply'd to their *proper* and *well-disposed* Subjects; yet nothing can be affected on the contrary: For, as a *Pound* of Lead in the one End of the Scales cannot be stirr'd by *Fifteen Ounces* in the other; so the Pressure of the *Moon*, being so far over-power'd by the *Weight* and *Consistence* of the *Quicksilver*, loseth its *first Stroke*, and for want of giving a *beginning* to its *Libration*, all which follow are spent in vain: And as for the Weight of the *Atmosphere*, tho' never so much increased, it cannot impress any Motion upon the *Sea*, as being *equally* spread over its whole Surface at once; but rather keeps it *steady* in its Natural Posture.

But, on the contrary, admit the Weight of the *Atmosphere* were apply'd to the *Ocean* with the same Advantages that the Pressure of the *Moon* is; and the Effect would be advanced to a vast Excess: For, suppose her *first Impulse* shou'd depress the *Ocean's Surface Thirty Foot*, in proportion to the *Quicksilver's Thirty Inches* in the *Barometer*; to raise, by *Rebound*, an Undulation *Thirty Foot* above the Natural Level of the *Sea*; and the *Second* shou'd raise an Undulation *Thirty Foot* higher than the *First*; and the *Third* another as much higher, and so forward; or, allowing only
a *Foot's*

a *Foot's* Abatement to every Undulation *fifteen* times together ; and the *Product* of their Rise would amount to no less than *three hundred Fathoms* : so vast an Advantage doth the Pressure of the *Moon* make of its *constant* and regular Application to the *Sea*, as shall be shew'd in the two following *Sections* ; and so utterly is the Weight of the *Atmosphere* defeated, *without it*, of any sensible Effect wrought upon the *Ocean*.

And all this while, the *Objection* runs upon this double Mistake ; to wit, that the *Tide* is raised merely by the *Moon's single* Pressure, from *Five Foot* to *Fifty* : Whereas, on the one side it is depress'd so low, by the *Additional* Impulsive Rays of the *Sun* ; and rais'd to that Height, by the special *Concurrence* of the contracting *Shores* ; acting *counter* to each other as several *Seasons* ; as will hereafter plainly appear, on due Occasions.

And if it be further urg'd, that neither the Influence of the *Sun* or *Moon*, by way of Pressure, is as perceptible to *Sense*, as the least Blast of *Wind* ; nor, consequently, so able to produce so vast an Effect as the Motion of the *Tide*, with all its Diversity. It is reply'd ; that, altho' the Weight of the *Atmosphere* be no more perceptible to our *Senses*, than the aforesaid Influence ; yet it is *heavy* enough in it self, (did it not *alike* support us on all Sides at once) to clap us so close, and fix us so fast to the Ground, that the strongest *Giant* wou'd be less able to stir either Hand or Foot, than to remove a *Mountain* : And, notwithstanding the *Wind's* quick Motion makes a forcible Impres-

sion upon our *Senses* ; yet, were it put to as peremptory a Stop by some *Obstacle*, as the aforesaid *Pressure*, is by the Surface of the *Sea* ; 'twould not suffice to extinguish the Flame of a Candle.

And, as to the Production of the said *Tidal Effect* : Since the *Wind*, notwithstanding the *Thinness* and *Levity* of the Air whereof it consists, compared to the *Density* and *Gravity* of the Water which is mov'd by it, falls so far short of matching it, as *One* does to a *Hundred* ; yet, by *beginning* to ruffle its Superficies with gentle Blasts ; and raising 'em afterwards by *Degrees*, and still giving 'em due *Application* all the while ; can, within a few *Hours* space, disorder the *Ocean* into so tumultuous a Crowd of mountainous Billows, as 'twould crack all the *Engines* in the World, to sustain any one of 'em for a single *Moment* : 'Tis no wonder that the said *Pressure* so qualify'd, as I have already declared, shou'd by the said means of *reciprocal Libration*, and by the like progressive *Degrees* produce the more Periodical Motion of the *Tide* ; both as to its Substance and all its Diversity, according to the different Energy of its *Application*. Thus much being alledg'd, for the Production of the *Tide* by the *Moon's Pressure*, in general Terms ; let us see *how* the different Motions of the *Moon* respectively influence the *Tides* of the *Ocean*.

S E C T. IV.

The Diurnal Course of the Moon, and the Motion of the Tide adjusted ; and the Regularity of her Pressure's Application demonstrated ; and how she maketh a Primary and a Secondary Tide, with one Revolution.

HAVING already determin'd the Cause of the Tide in general ; and described the manner how it is produc'd : To observe Order and Method, I am now to give an Account of the Moon's *Diurnal Course* from East to West, as being her most Regular and Common Road about our Globe ; before I digress to her *Menstrual* and *Annual* Motions, which are Deviations from it. And, to speak intelligibly,

First, It is to be noted (to have but one Chase in view at once), that I place the Moon upon the *Equator*, as being the *Mean* between the *Tropicks*, which she never transgresseth above Six Degrees : And (to hunt down one Difficulty before another be started), I make her Motion to be *concentrical* with the *Earth*.

Next, whereas she produceth *two Tides* with one Revolution ; to describe their Production more exactly, I shew how it is perform'd gradually in *four times six Hours* ; I mean *Lunar Hours*, which are about *two Minutes* shorter than the *Solar*.

Thirdly, forasmuch as they are produc'd by her *Pressure*, which cannot affect (immediately and

and directly), more than the *one Half* of our Globe at once; I assign 'em *Both* to the *same* Impulse; the one as its *Primary*, and the other its *Secondary* Effect; tho' they be produc'd after very different Means.

Finally, When I say 'tis High-Water upon the *same Meridian* with the Moon, it is to be understood of that Tide which is caus'd by Rebound between the *Tropicks* and the *Polar Circles*; as being caus'd by her *Pressure* which is made at the *same Time*, and upon the *same Meridian*, near the *Equator*. Thus much being Advertis'd,

First, It is to be consider'd, that her Lines of Pressure, co-extending to our whole Hemisphere of the Globe at once, begin at her rising in the *East*, to affect the Ocean up to our *Meridian*; and as she mounts higher towards her *Southing*, those Lines are not only contracted in Length a *Semidiameter* of the Earth; but still grow more compact for the space of *Six Hours* together; and fall more directly upon its Surface, to make a deeper depression upon the Sea, between the *Tropicks*, till she be advanc'd to her greatest Height; while the *Two* aforesaid Undulations are rais'd by Rebound collaterally on each Side of her Passage; and still swell and dilate themselves (to make High-Water) towards the *Poles*, till her Pressure be at a stand.

And for the next *Six Hours*, when she declines into the *West*, and withdraws her Light and Pressure from our Hemisphere by the *same Degrees* that she had advanc'd 'em; those Undulations must devolve back again, with as great
Precipita-

Precipitation towards the *Equinoctial Line*; not only to fill up the vast *Vacuity* left by her Absence, but also to remount the Water's Superficies in the *same Place*, as high *above* the Ocean's Natural Level as it was shrunk *below* it before; that, as at her *Southing* was made High-Water towards the *Poles*; so now, at her *Setting*, it is upon the *Equator*.

And in the *Six Hours* space after her *Setting*, when she is hastening to the *Meridian* of our *Antipodes*, that *Equinoctial Tumour*, left behind her upon the Ocean on *this Side* of the Globe, must descend again by its own Weight, as low as from whence it rebounded before; to make as great a *Depression* upon the Sea's Superficies on *our Hemisphere*, and at the *same Instant*, that the Moon does upon *theirs*; to make two *diametrically opposite Tides* at the *same time*; there a *Primary* one, as caus'd by her immediate and direct *Pressurè*; and here a *Secondary* one, as rais'd by the *Descent* of the said *Undulation* left upon our *Meridian* at her *Setting*.

And in the *last Six Hours*, while the Moon returns to our *Horizon*, the Sea on *our side* of the Globe, which was *secondarily depress'd* to its lowest *Ebb* by its own Weight, rebounds again very opportunely to its *former Height*; that, while the *Tumour* hangs as it were suspended in the Air, she may give her *Second Impulse* a Regular Application, to drive it down again *more forcibly*, in a joint Concurrence with its innate *Ponderation*: And begin this *Second Revolution* with more *Vivacity* than it did the *First*; and the *next* with more than *this*; and so the *rest* that follow progressively, by a *Circular Repetition*; till they arrive

rive at that flint which is to be *constantly* maintain'd, and as it were *repeated*, by an Alternate Vicissitude ever after.

For, the Moon still renewing her Pressure, and taking it off again by *equal* spaces of Time, at every *Six Hours* end; and this *Primary* and immediate Impression, setting its Stamp upon the *Secondary* one, (which immediately follows it, and is produc'd by a concurrent Depression of the Water's Gravity, as being the *Adequate* Effect of its immediate Cause;) each alternately *pursues* the other so close, as to leave no *Vacancy* in point of Time, to intervene between 'em, which the Moon's *second* Impulse cannot supply, by the more constant and regular Application of her *successive* Revolutions.

But, after the Motion of the Sea be *exactly* adjusted, by a few such Amendments, to the *common* Course of the Moon; and the Tide's Undulations are rais'd to a competent Height, by a proportionable Number of her *repeated* Impulses, regularly apply'd; they *acquire* a Motion *proper* to themselves, and become more *Equitemporary*; let their *Librations* be never so much increased or diminish'd: yet they adhere all the while no otherwise to the Course of the *Moon*, than a good-going *Pendulum-Clock* does to the *Sun*; so as to stick close to their *mean* Motion, let the *Real* One vary how it will; notwithstanding, so as still to hit their stated Occurrences to a Point: A convincing Argument, that as the Motion of the *Clock* has a dependance on that of the *Sun*, by the contrivance of *Art*; so this of the *Tide* has its Dependance on the Course of the *Moon*, by the Order of *Nature*; yet all this while, with
due

due regard to *Another* of their own, to *Qualify* it : And it is no less necessary, than that the Increase and Decrease of *Day* and *Night* shou'd depend on the *Rising* and *Setting* of the *Sun* ; or the different Constitutions of the *Four Quarters* of the *Year*, on his respective Arrival to the *Four Cardinal Points* of the *Zodiack*.

Thus far the Motion of the *Tide* is adjusted to a *Mean Time* with the *Diurnal Course* of the *Moon*, whereon it depends ; and (forasmuch as is yet consider'd) it shou'd keep to a *constant Height* ; but being found by Observation to fall short of it at *some Seasons*, as much as it exceeds it at *others* : It is next to be examin'd,

S E C T. V.



How the Tide's Menstrual Increase is caused by the Concurrence of the Sun's Influence with the Moon, at her Change and Full ; and it's Decrease for want of it, at her Quadratures.

THUS far I have described the constant Course of the *Tide*, as depending solely upon the Pressure of the *Moon*, turning Concentrically about the *Earth* ; and making the depending *Tides* constantly equal, without any variation : Now, in regard the *Menstrual Increase* of those *Tides* constantly makes *highest Floods*, when she is either in *conjunction* with the *Sun* at her *Change*, or in their *opposition* at her *Full* : And the Decrease is at its *lowest Ebb* when

when she is in her *Quadratures*; those Floods and Ebbs must be influenced by 'em *both*; the Floods, by way of *Addition*; and the Ebbs, of *Subtraction*; that neither an Effect may be put without a sufficient Cause, nor the Cause may lose its proper Effect.

Again, forasmuch as *Light* and *Heat* are the chief and most powerful Influence of all Planetary Bodies; and the *Sun* particularly distinguishes himself from all the rest, in being the Sovereign Origin of 'em *both*; I am to demonstrate that his Rays, as impregnated therewith, are the most efficacious and proper Causes to produce the said *Tidal Variation*; and withal, that the Ocean is as well disposed to receive 'em.

First, Concerning the Sun's *Light*; its Motion being progressive, and the Particles whereof it consists extremely small, it passeth thro' the Air down to the Sea, as thro' Glass or Crystal, without any great Impediment; yet since we find it strongly reverberated by its *Reflection* from the Ocean; we may safely infer it to be *stop'd* in part, and resisted correspondently, in its Career, by the Opposition of the *Salt-Water*; as well as of any other material Substance; and to fasten Strokes upon it of a determinate Force; and what it wants of *Weight*, it redoubles in Effect by the *Celerity* of its Motion; and by this means, acts most powerfully upon the Organs of *Animals*; and drives, as it were, Wedges of Heat into the Hearts of Plants, and Things Inanimate, and separates their more Solid Parts: All which are confessedly the Properties of *Bodies*, and can
only

only belong to Material Substances ; and consequently enable it to operate upon the *Sea*, as one Body does upon another ; and powerfully so, by due *Application* thereto.

Again, the reflex Heat of the Sun seconds the direct Pressure of his Light with a retorted Impulse upon the *Sea* ; by raising Vapours and Exhalations into the Air, that gravitate upon the Surface of all Liquid Bodies ; to that Degree, as to raise the Quicksilver in the *Barometer*, by the preponderation of the *Atmosphere*, from 27 Inches (the ordinary Weight of the common Air) up to 31, (which is the Additional Pressure caus'd by the Energy of the Sun's Heat) as is found by Experience ; the Overplus of those Four Inches of Quicksilver being Equiponderous to Four Foot of Water ; and equivalent to the Pressure which it imposes upon the Surface of the *Sea* ; in proportion to the Power it actually exerts ; which amounts to the Pressure of Four Foot of Water, spread over the whole Surface of the Ocean.

Besides, those Vapours and Exhalations, when they are rais'd, grow more Ponderous by their recoil against the Impulse of their Mover ; as a Pound of Lead, while 'tis only kept steady in the Air to the same Height, weighs no more than a Pound ; but if it be lifted Higher, increaseth its Pressure proportionably to the increase of its Motion ; as, on the contrary, if it be let fall again, its pressure decreaseth as much, till at last it weighs no more than a Feather : Moreover, since the Sun spends not one half of his Diurnal Revolution, in raising the said Vapours and Exhalations, as we find by experience, in the Dew which

which fall again *betimes* in the Afternoon Energy of his Operation seems considerably improv'd, that can raise so vast a Wave High, in so short a Time.

Secondly, That the Sun's Influence fall short of producing its proper Effect on the Sea, for want of due Application of Heat and Light spread themselves over the Hemisphere, as universally as the Lines of Latitude do. 2. And also affect the Surface of the Ocean more intently between the Tropics, to depress it by their Impulse more effectually, and as remissly towards the Poles, to give it liberty to rebound more freely there; the Force and Efficacy of his Influence increaseth equally with hers, till Noon; and is quite taken off again, before Night. 3. In different Seasons of the Year, what the Sun respectively gains at one Season it loses at another.

But, on the contrary, the difference of their Diurnal Revolutions divide the Force, and lessen the Efficacy of their Force, for want of due concurrence to produce the same Effect. For, at their Conjunction, his Rays and hers, following the same Lines of Pressure, following the same Direction, send down jointly their most compact Force, to raise the highest Tide, and the lowest Ebb; but the next Day, coming both up at once to the same Meridian, their Force being divided they fall short of their former Effect, by a Sixth Part. 4. Their Third return, more than that; and so progressively for Seven Days together, till the End of the First Quarter; the Motion of

adhering to the Course of the *Moon*, as is
and by Observation.

But after her *Quadrature*, till their *Opposition*,
Strokes of Light and Heat, and Hers of
Assure, fall upon the *Diametrically-opposite* Un-
dulations; and as diversly affect 'em, in their
different *Hemispheres*; hitting 'em daily more
thickly, and advancing 'em higher and higher,
means of Depression; till the *Plenilunary*
reach the height of That, at her *Change*;
the *Manner* of their Operations be very
different: For, whereas at her *Change*, they
act, with united Force, in effect, a double Im-
pulse with one single Stroke, to one and the
Undulation, letting its *Opposite* pass disre-
garded: Now, on the contrary, at her *Full*,
they give their Strokes single and apart, to
each of the *Diametrically-opposite Meridians*; to
each both the Emergent Undulations at once,
raise 'em to their *Novilunary* Height; by
producing the same Effect as before, tho' by a
different Manner of Operation: Just, as
in a *Pendulum* is mov'd by a *Clock*; it mat-
ters not, as to the Effect, whether it be rosd
in One way with a double Force, or Both ways
with a single One; for, in both Cases, its *Vibra-*
tions are kept up to the same Height.

lastly, While the Constitution of the Sea
continues in its last Disposition, for this new
reflexion of the *Sun's* Influence; and the
is kept Actually in Motion by the Pres-
ence of the *Moon's Diurnal Course*, to receive it;
nothing else can be required to raise it, at due
times, to a Height extraordinary, beside the
said Influence, so apply'd.

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As,

As, when we have put a *Pound* into one End of the Scales, and endeavour to raise it, by casting *Ounces* into the other; tho' it stirs not, till the Addition of the *sixteenth* Ounce brings both Ends into an *Equilibrium*, and the *seventeenth* overcomes the Friction of the *Axis*; yet after That, every *Scruple* that is added gives an *Increase of Velocity* to its Motion: So in our present Case, be the Super-influential Power of the *Sun* never so weak; yet, assisted by the aforesaid Advantages, of a Regular Application; it sufficeth to advance the Ordinary Height of *Tides* (which are already put into Motion, and kept on Foot, by the *Diurnal Pressure* of the *Moon*) to an *Extraordinary* Height; and serves to discriminate Each from Other, with that indefinite Variety of *Increase*, forward, till those *Luminary's Conjunction*, or *Opposition*; and of *Decrease*, back again, till her *Quadratures*; successively, thro' their *Menstrual* Revolutions.

But, lest the Height of the *Tide* may seem too much Advanc'd at the *Change* and *Full*, above that which happens at the *Quadratures*, to be rais'd within the Space of *seven Days*, by the additional Rays of the *Sun*: It is farther to be consider'd, That the Force which they add to the Pressure of the *Moon*, (by their Concurrence at her *Change* and *Full*), for the Increase of the *Tide*, is not only *subtracted* at her *Quarter-floods*; but directly occurs, in the same measure, to suppress it; so that the *Sun's* Influence causeth different *Tides*, at contrary Seasons, in a double Proportion to its real Force; inasmuch as it does not only withdraw, what was *Auxiliary* before; but renders it afterwards *Adverse* to the same Degree, by a contrary Application.

Hence

Hence it comes to pass, That the *Mensrual* Increase of the *Tide*, according to its whole Extent, doubles the Highest, which the *Sun's* single Force cou'd directly give it: Forasmuch as in the *First seven* Floods, after the *first* or *last Quarter*, it only takes off the Impediment of the *Opposition*, which is made to the Rising of those *Quarter-floods* to their usual Height: Whereas afterwards, for the other *seven* before her *Change* and *Full*, by the joint Concurrence of His Influence with Hers, they be as much *advanc'd* above it; and so by acting counter to itself at different Seasons, coextends to the whole Effect by its *contrary* Application, as aforesaid.

Besides, the superadded Assistance of *Inclining Coasts* and *Shores*, (which affect not the *Neap-Tides* at all, that can hardly reach 'em); helps to raise These more *Advance Floods* to that extraordinary Height; as will more fully appear hereafter.

S E C T. VI.

How the Sun's and Moon's Annual Courses thro' the Zodiac, jointly diversify the Depending Tides, and raise the Equinoctial Tides higher than the rest.

IN the Two precedent Sections has been shewn, *First*, The Application and Efficacy of the *Moon's Diurnal Pressure*, to raise and continue the *Common Tide* to its constant Height. *Secondly*, How effectual the Accessory Light and Heat of the *Sun* has prov'd, for Diversifying those *Tides*, by way of Increase and

Decrease respectively, to their *Monthly Aspects*. Now, concerning their *Annual Courses*, thro' the *Obliquity of the Zodiack*; It is farther observ'd, that all along their Progress, from the *Tropicks* to the *Equator*, (where they send down their most *direct* and *compact* Influences, and take their *largest* Compass about Our *Terraqueous Globe*); they jointly raise the *Intervening Tides*, by successive Degrees, till they reach their *Equinoctial Pitch*, which surmounts all the rest; according to the *Theory of the Tide*, laid down already on several Occurrences, in former *Sections*.

But, to supply *Now*, what was omitted *Then*; It is farther to be consider'd, that the *Planetary Motions* being *Elliptical*, and consequently their Influences *more* and *less* Intense, according to their several *Distances* from *Us*; even the *Equinoctial Tides* may be *augmented* by the Moon's *Perigeum*, and the Earth's *Perihelium*; and their *Apogeums* and *Aphelions*, may *Anomalously diminish* them as much, whether they be *Conjunctively* taken, or *Apart*, as it shall happen, to an Indefinite Variety.

Again, Forasmuch as Strokes of the *same direction* make deeper Impressions, than those that are *disperate*; and the *Moon* sticks not so close to the *Ecliptick*, as the *Sun* does: Upon every *Approach*, or *Declination*, she makes her Strokes more or less *Effectual*, upon the *Sea's* Surface: Besides, as by their Access to the *Sea*, and Recess from it, their Course, with respect thereto, is either Accelerated, or Retarded; the Motion of the *Tide* must, in some measure, be so too; with several other *Anomalous Differences*, both of *Excess* and *Defect*; which are rather

an Object for piercing Wits to discover, and for acute *Speculation* to manage; than a fit Subject for dull *Experience*, and short-sighted *Observation* to be employ'd about; so that they may here be well omitted, where nothing more than *Brevity* and *Clarity* is intended.

But, what falls within the Cognizance of them *Both*, is, that the intervening *Aether*, (by whose Means the Pressure of the *Moon* is suppos'd to affect the *Sea*,) is of a yielding and compressive Temper; and withal, the Body of *Water* which is affected, of a ponderous and liquid Constitution: Hence, the consequent Motion of the *Sea*, cannot be suppos'd to keep exact Touch with the Impulse of the *Moon*; but the *Tide* which is rais'd, must fall short, both in *Height* and *Speed*, of the design'd Effect: And upon every *Alteration*, either of *Speed* or *Causality*, it must rather observe Her *Mean Motion*, than Her *Real Course*: As a long and heavy *Pendulum*, little regards the *Unequal Draught* of the *Clock*; but rather sticks to a more regular *Swing*, in due proportion to its *Length* and *Weight*, to keep the *Index* to an exact *Time*.

Moreover, When the Motion of any Liquid and heavy Body, is gradually Increased, by the Assistance of *Reciprocal Libration*; it will go on Increasing, tho' not at the same Rate, after the Force of the Mover begins to abate, till it come up to an *Equilibrium* with the Remainder: Hence, the highest *Tides* regularly happen, *two* or *three Days* after the *Change* and *Full*, when the Force of the *Moon's* Pressure begins to decay, if they meet not with some *Anomalous Impediment*, to stop their Career.

The Conclusion is, that the *biggest Tides* possible must happen of Course, when the *Sun* is at his *Equinox*, and the *Moon* upon the *Ecliptick*, and withal in her *Perigeum*; *three or four Days* after the *Change*, or *Full*; and must swell Highest, either upon the *Equator* at their joint Concurrence from the *Atlantick* and *Ethiopick Oceans*; Or, as I conceive, about 45 Degrees of *North* and *South Latitude*, where their *Collateral Tumours* most abound: And this *Recapitulatory Instance* will serve well enough, to remind Us of the *Causes* already assign'd, for the *Increase* and *Decrease* of the *Tides*; from the first *Depressions* made upon the *Sea*, to their full Advance to their *Equinoctial Height*.

But to proceed farther, to weigh the just *Advantages* of the *Power*, which the *Sun* and *Moon* have to Act; and the due *Disposition* of the *Air*, which is the *Medium* that both conveyeth and enforceth their *Influence* upon the *Sea*; as also the *Capacity* of the *Subject*, *Water*, to receive the *Effect*; with a *Liberty* to make such *Additions* and *Subtractions*, as the *Rules* of *Art* direct, and the *Laws* of *Motion* allow: It plainly appears, upon the *Principles* already laid, and the *Method* which I have follow'd; that the *Motion* of the *Tide* hath ever adhered, and must still stick close to the *Course* of the *Moon*, (in concurrence with That of the *Sun*) for *Days*, *Months*, and *Years*; *One Age* after *Another*, without any *Observable Deviation*.



C H A P. II.

*Of the Tides of the Ocean, as being
bounded by Coasts, and Shores.*

SO punctually, as I have already demonstrated, wou'd the Motions of the Tide observe the Course of the *Sun* and *Moon*; and all their Diversities might as exactly correspond to each other, according to the *Scheme* I have drawn, if the *Extent* of the Ocean's Superficies were *boundless*; and spread *Universally* over the Face of the whole Earth; to receive their Impressions in full Measure, and comply with their Influences without any Restraint: But, on the contrary, the Ocean being actually *confined* on all sides, by *unequal Shores* and *shoaly Bottoms*, to intercept its Motion, before it begin; and likewise to interrupt its Course, before it should end; *disordering its Undulations*, with irregular *To's* and *Fro's* all the way: I am to proportion my Measures accordingly: so as to make it plain, That, when all Circumstances are duly consider'd, the whole Diversity of the Tides, so caused throughout the World, is fairly accountable, and without much Difficulty deducible from the same Principles.

S E C T. I.

High-Water stated at the Intersection of the Equator, and the First Meridian; as being the Place least obnoxious to any Confinement, by Neighbouring Coasts, &c.

NOW, to pursue the strict Dependence of the Tide, especially upon the Moon, under the aforesaid Confinement of the Sea; and speak more particularly upon that Subject, as to Matter of Fact: I must fix the Center of my Observation and Discourse, on that Part of the Ocean, where the *First Meridian* cuts the *Equator*, at Right Angles; as most abstracting from the various Irregularities of Shelves and Shores; or, That Great *Meridian*, which divides the *Atlantic* and *Ethiopic* Ocean jointly, at the most equal Distance from those Three Parts of the World, which confine it; from *America*, on the *West*; and from *Europe*, and *Africk*, towards the *East*: (the Ocean lying open there, towards the *North* and *South* from the *Equator*, as far as the *Arctic* and *Antarctic* Polar Circles:) To state aright the Flux, and Reflux of all the Tides, that either depend upon it, or have any Analogy to it, in other Places.

Having therefore firmly establish'd, in my precedent Discourse, that the Pressure of the Moon causeth the constant Motion of the Tide; Again, that her Pressure still *increaseth*, till she reach the *Meridian* of any determinate Place; and farther, that it is most intense upon

On the *Equator*; and after all, I have shewn at present, that the *Ocean*, upon the said *Point*, is best dispos'd to receive the Impression: Hence I may safely conclude (since as often as the Cause is actually put, and Subject well dispos'd, the Effect must necessarily follow;) That it is *Low-Water* upon the said *Point* of Intersection, as often as the Moon arrives to that *Meridian*; which is the Position to be prov'd.

Now, to reverse my Discourse, and argue from the Effect to the Cause; it is constantly found by Observation, that it is *High-Water* towards the Pole, (v. g. in our Northern Latitude of *England*,) upon the said *Meridian*, when the Moon is also upon the same Line, at the *Equator*; and by consequence, the Ocean must be most depress'd there, to raise the Tide here by Result, from that Depression, as its proper Cause; since the Surface of the Sea cannot be rais'd in one Place; without an equal Depression in another: So that, whether we argue from the Cause to the Effect, or the Converse; the like is concluded as before, in the way of Reason: And our farther Recourse must be to *Navigators*, and their *Pilots* for Instances, to shew the same by plain Experience, and Matter of Fact.

§.

To establish this great and important Truth, by recourse to the *Mariner's Observation* for Matter of Fact; the *Streight*, wherein the Experiment is to be made, lying between *Guiana* in *America*, and *Guinea* in *Africk*; the *English Pilots*, belonging to those Places, ought to be

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consulted; at what Hours, the Water flows on both Sides of it; to gather thence *how*, and *when* the middle Channel, more, or less abounds with Water: And to begin with the *West-Indian Pilot's* Account, which is the shorter, and of quicker Dispatch: He informs us, that

‘ Before the *ſ. Cajana*, which lieth Five Degrees to the Northward of the Equator, and about Twenty Degrees to the Westward of the Intersection aforesaid, an East and West Moon makes High-Water there, on Change and Full-Moon Days; which is the only Instance that he produceth of the Flood, within Eight Degrees of the Equinoctial Line, on that Side; or that can be concern'd in our present Enquiry.

But, to come up close to the Line, and about Five Degrees nearer the said Intersection; the Flood, as all Navigators observe, fills the Mouth of the *R. Amazonas* at $VI\frac{1}{4}$; or a Quarter later than the *ſ. Cajana*; the Entrance of the former River being much larger, and full of Islands with Inlets, to take up more Time before they be full: And it cannot be doubted, that the same Atlantick Flood, alike affects the *Brasilian* Shore, all along from thence to *Cape Roque*, (its utmost Eastern Point,) with near an East and West Moon; that is, at VI, or thereabouts.

And passing over the Streight, to the opposite Shore; our *Guinean Pilot* presently informs us; First, ‘ That at River *Serbera*, upon the Edge of that Coast, the Water flows with an East and by South Moon; that is, at $VI\frac{2}{3}$: And (following the Shore to the Eastward,) an East Moon makes High-Water at *Swine*, at VI:
And

And a little farther, at *Gojawan*, a N. E. and by East, and an E. N. East Moon, makes the Water flow at $III \frac{2}{3}$, and at $IV \frac{1}{2}$: And passing along the same Coast to *Caran*, an East Moon floods there, at VI; as also an East and by South one, at $VI \frac{1}{3}$: At *Bening*, an Easterly Moon fills all full, at VI: And at *R. Rey*, an East Moon, and an East and by South does the like at VI, and $VI \frac{2}{3}$: At *Bato*, and *Camaroon*, an East, at VI: At *Monamba's Floe*, an East, and an East and by South Moon, at VI, and $VI \frac{1}{3}$: At *R. Danger*, an Easterly, about VI: And lastly, that at *R. Gabon*, upon the Equinoctial Line, an East and by N. makes the Flood, at $V \frac{2}{3}$; which includes all the rest, (one excepted) both for Time and Place, as will be shewn hereafter.

S E C T. II.

Reflections upon the precedent Account of the Tides, near the Equator, in the Channel between *Guiana* and *Guinea*.

HAVING already consulted both Reason, and Experience, about the Time of High-Water, as far as both can assure Matter of Fact, upon the Coasts of *Guiana* and *Guinea*, near the Passage of the *Atlantick* and *Ethiopic* Ocean's Intercourse between them: I am now to make some Reflections upon the pass'd Account, for the farther Elucidation, and Establishment of so important a Point; which sustains

sustains the whole Frame of my following Discourse upon that Subject.

First, It is observable, that Six of those Thirteen Places, which the Pilot for Guinea remarks, have High-Water absolutely at VI, without any Variation: to wit, *Cajana*, *Swine*, *Bening*, *Bato*, *Cameroon*, and *Danger*; which, being so well agreed, and near an equal Number with all the rest, which are divided; ought to render that Hour regular, and to be observ'd: Besides, Four of the Dissenters make but Half-Tides at different Times; as *Serbera*, *Caran*, *Rey*, and *Monamba*; which swell at VI, and withal at $\frac{1}{2}$ after; which plainly proceeds, either from the Unevenness of their Shores, or the shoaly Bottoms which retard 'em: And as for Two, of those Three Dissenting Rivers; to wit, *Gabon*, and the *Amazones*, which are more positive in their Mistake, and remain unaccounted for; the Former, makes at V $\frac{1}{2}$; and the Latter, at VI $\frac{1}{4}$.

Whence it is to be noted, that at all the abovesaid Thirteen Places, (*Gojawan* excepted) the Sea is full, either exactly at VI, (their common Standard;) or within $\frac{1}{2}$ before VI, or $\frac{1}{2}$ after it.

A Difference so inconsiderable, and the Inequality of the Shores, which occasions it, so moderate; as to divert the depending Tides neither Way, from the Rising (and Setting) Moon, above Forty Minutes; for all that Tract of Sea, between R. *Gabon* and *J. Cajana*, from East to West, above Twelve Hundred Leagues: yet at *Gojawan*, it floods at III $\frac{1}{2}$, and IV $\frac{1}{2}$; which is so preposterously early, and withal so disagree-

disagreeable to its Fellows, that it merits an *Occasional Consideration* extraordinary; and such as is by no means applicable to any of the rest. Now

It is observable, that, to heighten this Irregularity, and wical to remove the Difficulty; the *R. Swine*, which lies next before it, flows precisely at VI; and *Caran*, which follows next after it, at VI $\frac{2}{3}$; their Shores being pretty equal, direct, and free from Shoals; to let the Coasting Current, when it brings their Tides along with it, pass smoothly by 'em, without any Impediment; whereas, on the contrary, the *Mouth* of the *R. Gojawan*, which gapes wide open to receive the Flood, has *C. Palmas*, which shoots it self *farthest* into the Sea beyond all other, close behind it; and gives the Coasting Current the most peremptory *Check*; and the first *Easterly* Turn, along the Coast of *Guinea*, after it has left *Brasile*; and backs the Flooding Stream into the River, with greatest Force and Precipitation; so as to swell its Tumour, upon the first Appulse to the Shore, by *Result*, so much sooner and higher; as not to be supported any longer to the same Pitch, after the Energy of that first Push is over.

And the Flood, (as we are inform'd from the Observation of an Ingenious Friend,) makes as preposterous Haste at *J. Cajana*, where it swells at IV; the Current driving it strongly, and *overhastily* upon the Shore; yet, according to our *West-Indian Pilot's* Account, it is not full, aloof off the Coast, till VI; where it continues Rising all the while, till it be at least Quarter-Ebb close at Land, where it swell'd highest

highest before : And the like happens at other Places, on the like Occasion ; as will be made appear hereafter, by many Examples : so effectually does that *most Irregular Tide* within the Compass of our Observation , contribute (when the Anomaly of *Currents* and *Shores* is adjusted) to our present Satisfaction. Hence,

It is farther observable, that the Flood pursues her Diurnal Course so close, as to affect no Two Places, of an *East* and *West* Position, at once ; but one after another successively, from *R. Gabon* to *J. Cajana* ; Flooding their *Meridians* all along respectively , at her *Rising* (and *Setting*) *Instants*.

Now, in regard the Ebb, keeps at the same *Six Hours* distance from the Flood , that the *Southing* Moon does from her *Rising* and *Setting* ; it must be *Ebb* at her *Southing* , where it was *Flood* at her *Rising* before ; thro' all that Tract of Sea, with the same Order of Succession ; as well in the *Passage* aforesaid, by the Intercourse of the *Atlantick*, and *Ethiopic* Oceans ; and with the same Moon , that has been already remark'd upon the *Guianan*, and *Guinean* Shores ; from *R. Gabon* to *J. Cajana*, for *Four Hours* Difference of Time, and *Twelve Hundred and Eighty Leagues* Distance of Place ; as aforesaid.

After all, since the joint Observation of our *Two Pilots* , co-extends to *Sixty Degrees* upon the Equator , and *Four Hours* upon the *Horoscope* ; and affects both the *Land* and *Sea* intermix'd, of all sorts of Positions ; the Motion of the Tide being adjusted throughout to the *Diurnal* Conduct of the Moon ; the same Observation may, by Parity of Situation, be apply'd

ply'd to all *other Seas and Shores* around Our *Globe*; whether they lie shut up by Land, as the *Ethiopick* and *Indian Oceans* are by the *Guinean* and *Arabian Shores*, towards the *North*; or as the *Atlantick* is by the *Brasilian* and *Guianan Coasts*, towards the *South*: Or else lie open into both Latitudes, as the *Pacifick Sea*, and the *Streight* aforesaid, do towards *North* and *South*: Yet the Conclusion still holds, that *there must always be Low-water upon the Line*, wheresoever the *Moon is vertical*; in case there be Sea-room, either towards the *North*, or *South*, or *Both*, to take a Tidal Impression.

Now, in regard the Tide by this Account, and thus Summ'd up, still *Flows*, on the said *Interfection*, at the *Moon's Rising*; it must consequently do the like, upon the same Point, at her *Setting* also; as being directly *Oppos'd* each to other, both in Time and Place: So it must also be at its *Lowest Ebb*, when she is advanc'd to the said *Meridian*, as being the *Mean* between those Two *Extreams*; as also on the *Opposite* to it, in the *other Hemisphere*, for the same Reason; and upon all other *Meridians*, and *Parallels* between the *Tropicks*, upon her Approach to 'em; Her Pressure constantly attending her Presence, in all Places, without exception: And, forasmuch as every *Depression* between the *Tropicks*, must raise a correspondent *Result* collaterally, towards the *Polar Circles*, upon the same *Meridian*; it must respectively make *High-water at once*, in both *North* and *South Latitudes*, when she reacheth their *Meridians*, if there be Sea-room for that purpose. Let us find, *First*, By Experience, that *there is actu-*
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ally such a Reciprocation of Tidal Tumours in the Sea ; and shew, *Secondly*, By Reason, the Manner *How* it is really Effected.

S E C T. III.

How the Tide is stirr'd up by Pressure, and continued by Libration ; and whither it extends its self, before it makes its Returns.

HAVING found by Experience, that it is Low-water at the Equator, when the Moon is actually *Southing* upon the same *Meridian* in Our Northern Latitude of England, as being stoop'd There by her Pressure, upon the Point of their Intersection ; and that, as the Tide is rais'd Here at her *Southing*, by Result ; so it must needs be let fall again at her *Setting*, when her Presence is withdrawn which supports it ; and so be set on, and taken off again *interchangeably*, at every Six Hours End, by *Libration* : And finally, that the same Six hourly Reciprocation, must (thro' the Analogy of Their Seas and Floods with Ours) be punctually observ'd all the World over : Hence it occurs to design its Periods of Place, as well as Terms of Time, both Here and Elsewhere ; and to shew *how* its Librations are perform'd, and *how far* they are extended, both in Our North Atlantick, and in the other Three Divisions of the Ocean.

Now, to consult Reason, as well as Experience ; the One End of the Tidal Balance must Rise and Fall, immediately upon the Equator ; where the Pressure of the Moon first sets its

Libration on Foot, both in Ours, and all the Seas aforefaid: And the *Other End* is to be Extended as far as the *Bottom* of the Ocean (which *reverberates* the Motion of its Results) directs it, according to the *Rules of Reflection*: So that the deeper the Bottom lies, the Tidal Tumour must Result at a greater Distance from the Place depress'd. Hence, its Depth being *Unfathomable*, farther Recourse is to be had for the said Distance, to *Observation*; which finds the Flood to swell *highest* between 45 and 50 Degrees of both North and South Latitudes: So that 24 or 25 Degrees (near the *Tropicks*) being the *Mean* between those Two Extreams, to wit, the *Equator* and the said *Parallel* of 45 or 50 Degrees of Latitude; it must be the *Axe*, whereon the said *Tidal Balance* turns, to make its Revolutions accordingly.

To begin (for best Acquaintance sake) with the Search of the *Atlantick Ocean*; the Tide is found to run highest, on the *European side*, on the Coasts of *France* and *Great Britain*, between 45 and 55 Degrees of North Latitude; and on the *American Shore*, it grows higher from *Terra Florida*, along the *Virginean Sea*, and decays not till it reacheth *Davis Streights*; but is continued even beyond 'em, by the favour of the *Inclining Coasts*: And altho' the Flood, which is the Counterpart of its *Libration* in that Ocean, near the *Equator*, exceeds not six or seven Foot in Height; yet the vast *Extent* of its *Compass*, makes it *equivalent* in Breadth; and able to fetch up the greatest Floods: For Example, Thole at *St. Malos*, and *Bristol*: Whereas at *C. Verde*, and the Opposite *West-Indian Islands*, which lie under the *Tropick*, at 25 Degrees of Latitude, which is their *Common Axe*; the

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same Tides, in passing it To and Fro, scarce make any Appearance at all; or even a sensible Variation of High and Low-water in the Ocean.

And to pass on to the *Ethiopic* side of the Line, we presently meet with a fierce and violent Flood, in the Chops of the Streight, between the Coasts of Guinea in *Africk*, and *Brafile* in *America*; which, being contracted on both Sides, by their Inclining Shores, even forceth Ships from their Anchors: And at the Other End of that Flood's Libration, the Tide runs as high from *Rio de la Plato*, and *Terra del Fuego*; that is, from 40 to near 60 Degrees of Latitude; as it does respectively on the Coast of Europe: Whereas at *St. Helen's Isle*, which intervenes as the *Axe of its Libration*, and lies at the same Latitude with *C. Verde*, on the Opposite side of the Line, it seldom exceeds a Foot; as is found by Observation.

And, to turn over to the Backside of *Peru*, we are often told of the high Floods which *Navigators* meet with in the *Pacifick Sea*, that set into the West-End of the *Magellanick Streight*, about 50 Degrees South Latitude: And again, we hear of the like in the *Gulph of Panama*, which lies within three Degrees of the *Equinoctial Line*; without the least mention of any Tide near the *Tropick*, that is Remarkable.

Finally, As to the said Libration in the *East-Indian Ocean* (which lies shut up towards the North), the Flux of the Tide, upon the Moon's Approach towards the Meridian, is constantly driven Sea-ward by her Pressure; as plainly appears, by the overhasty Return of its Reflux back again from the South, upon her Declina-
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tion into the *West*; not only to supply the *Vacuity*, left by her Absence; but withal to fetch up Two of the *greatest Tides* that are known in those Parts, and Both in the *Torrid Zone*; the One near the *Mouth of Indus*, and the Other of *Ganges*; to the Wonder and *Astonishment* of the *Inhabitants* thereabouts: So manifest it is, that *Low-water* still attends her *Presence* and *Pressure*, between the *Tropicks*; and *High-water* *Souths* as constantly with Her, *beyond 'em*; and that Each *succeeds* the Other in both Places, by an *alternate Reciprocation*.

Such are the *Revolutions* of the *Tides* in those *Four Chief Divisions* of the *Ocean*, and so manifestly they are perform'd by *Libration*; with repeated *To's* and *Fro's* from the *Middle* of the *Torrid Zone*, down as far into the *Temperate Ones*, and back again; as plainly appears by the *Instances* already produc'd for that purpose: Yet, forasmuch as those *Tidal Tumours*, neither hang *pendulous* in the *Air*; nor librate *Up and Down* therein upon an *Axe*, which properly sustains 'em; but *Raise* and *let Fall* each other, *Reciprocally*; by the *Protrusion* and *Subtraction* of the same *Portion* of *Water*; which follows the *Flood*, close to supply and sustain it, till the *Ebb* withdraws it again; and Both ways by *Flux*, and *Reflux*, alternately: Hence it occurs to shew, How such *Mountainous Billows* are translated *Backward* and *Forward*, with *Ease* and *Speed*, to so vast a *Distance*.

S E C T. IV.

The Collateral Result of the Tide's Undulations from between the Tropicks towards the Poles, in six Hours ; and their Revolution back again in other six ; is shewn conformable to Reason, and testified by Experience.

TO derive the *Tide's Undulations* (rais'd by the Dint of the Moon's Pressure upon the Sea, *between the Tropicks*), with a regular Course of Result from the Equator, into North and South Latitude: It is to be consider'd, that those Tidal Billows lie naturally extended East and West, from One side of the Ocean to the Other ; as being so directed by her Diurnal Course, which draws 'em Parallel to the Equator.

But withal, her Pressure being most Intense, where it falls Perpendicularly upon the Surface of the Sea ; and she still holding on her Course between the Tropicks, or thereabouts ; the said Undulations must as constantly be driven transversely, from the intervening Impression towards the Polar Circles, by way of Result ; which, after the said Pressure is withdrawn, must be devolv'd back again towards the Equator, by the Poise of their own Weight, according to the same Degrees whereby they were mounted ; the Moon, at their second Return, still giving 'em a Counter-jog, to perpetuate their Reciprocation.

Now, in regard the Course of the Tide, as Navigators observe, runs very High into the North, as far as Davis Streight ; as also to the
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Magellanick Gulph, which lies as far *South*; yet keeps Touch *both ways*, with the Moon's Impulse, which drives it Thither; it must needs perform its *To's* and *Fro's*, between the *Equator* and the *Artick* and *Antartick Circles*, backward and forward, in *Six Hours* apiece respectively; and Move each way *70 Degrees* of Latitude, in *Six Hours* Space, at the rate of *230 Leagues* per *Hour*; which to do near the *Shore*, or in *Shallow Water*, were Impossible.

Yet, if we allow the *Expansion* of the Ocean to be of equal *Breadth* from *East* to *West*, with its *Length* from the *North* to the *South* (as the *North Part* of the *Atlantick*, for Example, is equally *Broad* from the Coast of *Africk*, to the Bottom of the Bay of *Mexico*; as 'tis *Long* from the *Tropick of Cancer* to the *Artick Circle*;) The said Motion of the Tide, down the *Midst* of its Channel, will prove *smooth* and *easy* enough: For, if its *Area* were divided into *Square Inches*, no One of 'em needed, in all that *Six Hours* Space to depart from its Fellow, either backward or forward, more than *twice its Breadth*, to perform its respective Part of the Revolution; so as either to make their *Friction* difficult, or their *Sliding* by each other, even in the *Middle Stream*, where their Motion wou'd be *swiftest*, at all Perceptible.

Again, To allow the said Part of the *Atlantick*, a Profundity of *Depth*, proportionate to its *Expansion* in *Length*, and *Breadth*; the Water, so moved, must acquire a correspondent Volubility *Up* and *Down* to its *To's* and *Fro's*; and an equal Liberty to *Ascend*, or *Descend*, upon any Commotion, with more Ease; according to the Increase of the *Depth*, which

is occasion'd jointly, by its greater Distance from the *Shores* on each side, and from the *Bottom* of the Ocean; to Both which, the Water immoveably *Adheres*; so as to raise the *Highest Flood*, and let fall the *Lowest Ebb*, where the Channel is *Broadest*, and *Deepest*; as is manifest.

Now, seeing the Tide is Caused by *Pressure*, the Motion of its Gravitation must reach as far, as that part of the Stream, which is so depress'd, *preponderates* the Dead-Water, which either *opposeth*, or *surrounds* it; That is to say, to the *Bottom* of the Sea, how Deep soever it be; before it *Rebound* up again to the same Height, whence it descended: *Again*, forasmuch as it is driven *transversely* Both ways, from the *Perpendicular*; and deflects on each side of the *Equator*, alike towards *North* and *South Latitude*; it must fall upon the *Bottom* of the Sea, *Obliquely*; and be Reflected by it, at the *same Angle* Upwards, towards its *Superficies*: So that, where the *Point of Repercussion* is deepest, the *Emergency* of the Tidal Tumour must be *farthest off*; and yet be perform'd alike, in *Six Hours* Space; and must reach its utmost Stretch, into *Our North Latitude*, and as far into the *South*, by the Force of the *same Impulse*, and at the *same Time*.

Yet the *Mid-Sea Current* of Water, how volatile and far extended soever, needs not to Move, as to any determin'd Part, perhaps more than *Ten* or *Twelve Feet*, either *Backward* or *Forward*; since the Ocean is *continuous* throughout its Course, and the Tumour rais'd at the *One End* of it sufficeth to supply the *Depression*, whereby it was rais'd at the *Other*; and by

its Fall below the Ocean's Level, to remount There a Tumour equal to itself; and so they stir up Each other reciprocally, by a Counter-libration: As the Water in the One End of the Syphon, upon every Agitation, To and Fro, does the like in the Other End, at the same Time, by virtue of their Communication through the intermediate Tube which joins 'em, let their distance from Each other be what it will.

Besides, the Spherical Curvity of the Sea's Superficies, and the Obliquity of its Declination from the Horizontal Plain of the Equator, still meeting the Course of the Ascending Arm more directly, the Angle of Intersection is render'd more Obtuse: Again, its Ascending Stream being, as it were, alleviated by Reflection upwards, is Buoy'd up by the Peristaltick Gravitation of the surrounding Body of Dead-Water; which still Inclines it, by degrees, towards the Perpendicular; till at last it affects the superintending Arch of the Ocean's Surface, at equal Angles on every side; and raiseth a Protuberance upon it, without the least determination to any One Part, more than the Rest: As the Mariner well observes, who finds no Tide in the Middle of the Ocean, to obstruct the Course of his Ship, or drive It one jot from its true Longitude, or Latitude.

Nor needs the Navigator to complain, that the said Protuberance is any hindrance to his Ship's way, while he surmounts it; which riseth not one Foot in a hundred Leagues; any more than a Traveller can repine at the Unevenness of his Journey, from Edinburgh to London, in case the Oblateness of the Earth's Globe raiseth the Situation of the Latter, at least a Fathom higher

than the *Former*; Nor ought to discredit his *Own Observation*, as taken from a false or uncertain *Level* of the *Sea*, upon its *Tidal Tumour*, or *Detumescency*: A difference too small and nice, to be discern'd by the *Bluntness* of *Sense*, or discover'd by the *Shortness* of his *Instruments*.

So conformable is the *Result* of the *Tide's Undulations* from the *Equator* towards the *Poles*, and their *Revolution* back again, both to the *Laws* of *Motion*, and *Testimony* of *Experience*, as well in the *Pacifick Ocean*, as in the *Atlantick*: Both which lie *Open* to the utmost *North* and *South*, without any *Impediment*; and no less in the *Indian* too, tho' it be quite shut up towards the *North*: In All which, as I have shewn in the *Last Section*, the *Tides* run very *High* in the *Torrid Zone*; and in *This*, that they mount to an equal or equivalent *Height* in the *Temperate*, as being the *Counterpoise* to Each other.

Yet, because the said *Extremes* must admit of a *Mean* between 'em, to be the *Axe* of their *Libration*; Hence it is farther observ'd, That, whereas the *Tide*, on each side of the *Equator*, for the Space of about *twenty Degrees* on either hand, bears up to considerable *Height*; and from *forty Degrees* to *sixty*, reacheth the same *Height*, as being its *Counterpoise*: Yet, between *twenty* and *forty Degrees*, which is the *Axe* of their *Libration*, it grows scarce *Perceptible*; the *Tide* being upon a constant *Decay*, from the *Streight of Gibraltar*, till it *revives* again at the *Tropic*; and continues its *Increase* till it reach the *Equator*: But, from the *Latitude* of *sixty Degrees*, towards the *Poles*, as being the full *Period*

riod of its Course, on that side, it *Languisheth* a way of its own Accord, insensibly to almost Nothing; every *Libration* consisting of *six Hours*, and their *Reciprocation* of as many.

S E C T. V.

Of the Circular Diffusion of the Tide, from the Center of its Tumour, in Our North Atlantick Ocean, to its Eastern and Western Shores; At also towards the Tropick of Cancer, and the Artick Circle.

HAVING already drawn the Course of the Tide, from the Moon's *Depression* of the Sea upon the *Equator*; and rais'd its Tumour near the Middle of Our *North Atlantick Sea*, by *Libration*: Now, to enforce its Flood by its *Detumescency*, *Circularly*, towards all the Points of the Compass at once, by way of *Undulation*; No more is required, than what constantly happens, upon the Fall of a *Stone* into a *Pool* of *Standing-Water*; which presently sendeth forth *Circular Undulations*, after the same Manner: But, before we proceed to describe it,

It is to be *Noted*, That the *Center* of the said Tumour, cannot be affix'd, with a *Geometrical Exactness*, to any *Point* or *Degree* of *Longitude* or *Latitude*, till the *Depth* of the Sea (whereon its *Angles of Incidence* and *Reflection* depend) be as precisely known, as either the *Length*, or *Breadth* thereof; Nor can the *Space* of Sea affected by it, be confin'd in a strict Sense, to
any

any determinate Compass upon its Superficies; as being effected by *too blunt* an Instrument, as the Moon's Pressure is; Especially upon so bulky a Body, as our Globe of Earth and Sea, conjoin'd; but must needs spread it self to a vast Extent, without any other Transfusion, than its own proper Magnitude.

Besides, Our North Part of the *Atlantick*, whereon this Tumour is rais'd, being of no Regular *Rectilinear Figure*; neither *Triangular*, (which it most represents), nor a *Polygone* of any determinate Sort; and That Tumour, which ought after a special manner to resemble It, consisting of *Water*, which must be *Curvilinearly* circumscribed, and yet be neither *Circular*, nor of any of the *Conick-Sections*; it cannot admit of any *Center*, in the strictest Sense; Yet, because the *Lines* of its Diffusion, must needs respect some *One Place*, more than the Rest; It will not be amiss, for *Illustration's* sake, to assign some *One Place*, which may seem more proper than any *Other*; and try how It will hit with *Experience* and *Observation*.

To assign the Point, as a *Center*, whence That *Diffusion* of the Tide proceeds; it seems most Congruous, to fix It upon the *Great Meridian*; (I mean That, whereby *Geographers* discriminate the Two *Hemispheres* of the *Old* and *New World*, Each from Other), which seems to divide Our *North Atlantick*, with most Equality, into *East* and *West* Parts: And where it is Intersected, by the *Parallel* of *Forty five Degrees* of the same Latitude, as a *Mean* between the *Artick Pole*, and the *Equator*: Now, to Evince at once, the Existence of such a
Tumour,

Tumour; whence the said Diffusion is Actually made; and that its Center is assign'd aright, from the Setting of the Tide every way outward from it, without any respect, or regard; I produce the following Instances, for Examples; And it is a generally receiv'd Opinion, and built upon common Observation; That, the Tide sets, from the Middle of all free and open Seas, directly towards their Shores.

Now, to point out, in some measure, the Center of its Transfusion in the Atlantick; It sets, upon all the Coasts of Europe, out of the West; And to shew that it is not afar off, it arrives, on the West Coast of Ireland, as being the Foreland of all Europe, at scarce three Hours after the Moon's Southing, upon That Meridian; as it does soon after, upon all the most Western Coasts of France, Spain, and Portugal, which lie near the same Meridian; without any regard to their different Longitudes: All which lie at near an equal distance from the Point aforesaid, and make High-water at the same Time; allowing only some few Minutes, to adjust the Computation, in proportion to the Inequality of their Shores.

Again, The Course of the Tide as little regards the Longitude of the Places which it affects, whether they lie East or West; Provided they lie at an equal distance from the said Meridian; and have an Open Sea between 'em; Hence the same Tide makes, at once, High-water on the Coast of New England, in America, and on that of Poitou in France, and much after the same Manner; As a French Writer reports it did, on July 16th, 1670, when there happen'd an Extraordinary New-Moon-Tide, in the Mouth of the River Pentecuit, in New-England,

England, at Eleven and a quarter in the Morning; and at Rochel in France, about Three and an half in the Afternoon; their Coasts, lying at seventy Degrees distance; which adjusts the Tide almost to the same Instant, in both Places; without any regard to the Diversity, of their East and West Longitudes, (the same Tide setting both Ways at once;) or the least Notice taken of the Moon's Absence from both Meridians.

And as to the flooding of the Tide, directly towards North and South; seeing the Ebb, which happens between the Tropick of Cancer and the Equator, in the South; and the Flood, which we here describe, swells up as its Counterpoise, between the said Tropick, and our Polar Circle, in the North; it cannot terminate in an Instant; but they must be gradually discriminated, each from the other, by a vast Space of the Ocean; which must be at once affected, by all possible Diversity of Heights of Water, reciprocally: Hence that Interval must be beholden to the progressive Diffusion of the aforesaid Tumour; to furnish it with a correspondent Tide, setting into the South, to what I have described, which flows towards the East and West.

Whence it comes to pass, that at the Island of Teneriff, which is the utmost Westward of the Canaries, and lies upon the first Meridian; 'tis not High-water, till the Third Hour after the Moon's Departure from it; because it lies at an equal Distance, from the same Ebullition of the Tide, with the Western Coasts of Spain, Portugal, &c. where it sets as aforesaid: And it sets out of the North, into the South, to demon-

monstrate its Origin to be the same with theirs, which *set* from thence to the *East*, and *Westward*; and so *sets all Three Ways* at once, as is manifest. And, by Parity of Reason,

We must conclude, That the Tide *sets* likewise from the *same Center* of its Diffusion, into the *North*: as the *Dutch* find by Experience, who *sail back* from their Northern Fishing *flower* by a Fortnight's Time, than they did thither. And all *Navigators* Attest, that the Water swells in *Forby's Passage* at VI; in *Davis's Streight* at VII $\frac{1}{2}$; and in *Baffin's Bay* at X; progressively towards the *North*, and in Spaces of Time, *proportion'd* to the Tracts of Sea which it passeth over, from the *Center* of its aforesaid Diffusion, to within *fifteen Degrees* of the Pole it self.

Hence it is as manifest, that That Diffusion of the Tide, spreads itself *circularly*, from the *Middle* of the *Atlantick*; as that the *Sun's Rays* flow from his resplendent Orb; And the *Center* of its Intumescency is as plainly remark'd, by its *setting outward* every Way from it; as the *Center* of the *Sun* is, by the like Effusion of his Rays towards their Circumference.

SECT.

S E C T. VI.

How the Tide is spread over the Atlantick Ocean, and communicates it self, to Other Seas, &c. And by its alternate Floods, and Ebbs, makes still a Restitution, correspondent to the Diversity of its Motion.

TO devolve the tidal Tumour, rais'd by the Last Section, in the Center of the Atlantick, to all its surrounding Shores; no more is required at present, than to let it sink down again, in the same Place, where it arose: Thereby to swell up, circularly, its Counterpile of Water, as far as the Compa's of that Ocean can afford Depth, and Breadth, for its Billows to swell, and roarl in full Measure: The said Tumour being, of its own Nature, every Way apply'd alike; and the Sea equally dispos'd, on all Sides, to receive the Effect of its Undulation.

First, This circular Transfusion of the Tide, expatiates it self farthest, in the shortest Time, towards the North, (where the Ocean is of the largest Extent); meeting with no occurring Shore, or Shallow, to countermand it back again: And it Falls by Degrees, till the Energy of the Tumour's Impulse, which first set it on Foot, be quite spent, by so long a Course: As a Stone, cast into a Pool of standing Water; spreads its Undulations circularly; and lets 'em fall still lower and lower, till the Commotion, languishing away by its Expansion, ceaseth.

Secondly, As to the Tide's Transfusion towards East, or West, where (the Ocean being Narrower; the Shore sooner occurs to the spreading Billow) upon its approach to the Soundings, it presently stirs up its Flux that Way: And being straitned by the shallower Bottoms, into a less Compass, must seem to make more haste forward: As a River runs smooth and slow, while it continues wide and deep; but grows swifter upon its restraint, in either Respect: And where it finds a Creek, or Inlet into the Land, it drives a stronger Current, thither-ward: And if the Mouth of the River, which receives it, be wider Sea-ward, and grow contracted afterwards, still its Speed is increased, in the same Proportion.

Now, because Salt-Water, whereof this progressive Tumour consists, is of a voluble and heavy Nature; it moves easily, after it is once set on Foot: And requires a proportionate Force, to stop its Career: And withal, being of too close and compact a Texture to be compress'd; That Part of it which is actually mov'd, must still push on, that which goes before it, forward; so as to swell the Ebbing-Water, which occurs, into a Tumour, by Anticipation; before the Flux of the Flood is self, of its own proper Course, can possibly reach it: As a Pole, being thrust forward at the one End but an Inch, drives on the Motion of its whole Length, at the same Instant, to the other, tho' it be at least Ell-long: So may the Tumour of the Tide pass on a League, while no determinate Part of its Flood reaches above a Furlong.

Hence

Hence it is, that our *English Channel*, having an *open Mouth* towards the Sea, receives its Flood *freely*; and having a proportionable *Depth*, lets its Tumour rowl forward, with a great deal of *Ease*; and *contracting* it self afterwards in both *Respects*, keeps it up at least to the *same Speed*, till it reacheth the *Sireight*, between *Dover* and *Calais*; where it returns up the *Thames*, with some *Abatement*: But to the Sea-ward of *Holland* and *Denmark*, soon falls away to Nothing, by its greater *Expansion*: Thus every single Tide, as it was rais'd originally by *Protrusion*, so it is still carried forward, by the *projective Dint* of its first *Impulse*, from the *Moon's Depression* of the Ocean near the *Equator*; all along the *Atlantick* up into the *Rivers*, where it expires.

Such is the *progressive Flux* of the Tide, from the first *Depression* of the Sea upon the *Equator*, to its result at the *Center* of the *Atlantick*; and it is thence convey'd thro' the *Narrow Seas*, up into the *Rivers*, till its final *Resolution* into *Calm-Water*: Now, in regard the first Tumour, was not only refunded back into that *Depression* which first rais'd it, by way of *Restitution*, and fill'd up that *Vacancy*; but also remounted it again to its own Height, by *Counter-Libration*; the like must be done to the said Tumour, by the *circular Billow*, which surrounded it; and, by *Parity of Reason*, the whole *Progress* of the tidal Flux thro' those *Seas* and *Rivers*, requires a continual *Regress* and *Reflux* of the like Nature, in all Places.

And, since the Moon sets on her *Pressure* at the *Equator*, and takes it off again, *periodically*, at every *six Hours* end; and correspond-

ly raiseth the *Atlantick* Tumour, and lets
it all again as often: The *secondary* Billow,
which is rais'd around it, must consequently
fall reciprocally, by counter-Libration;
give and return its Quota's of Flood and
Ebb on all Sides of its Circle, at once respec-
tively, to make an alternate Restitution in the
Sea: So must also the Floods and Ebbs, of
the *Dependant Sea*, and *River*, become re-
spective, and hit exactly the same Periods; as
every where the double Stamp of their
Commotion, impress'd upon 'em at the

1, forasmuch as the Flood was rais'd at
the Moon's *Protrusive* Pessure; and the
Water was let fall back again, alternate-
ly, by its own *Gravitation*, to fill up and sur-
mount the *Vacuity* left on the *Equator*; They
maintain every where, the same Reciprocation;
the Flood, by increasing progressively the Tu-
mour before it, by its *protractive Addition*;
the Ebb, by withdrawing as much Water
from it, by its *Gravitation*; leaving the Tu-
mour highest in the *Middle*, to maintain its
effective Impulse, forward; while a Sub-
sidence is made on the one Part, of what is
raised on the other, to make a through-out Re-
stitution, with regard to the common Level of
the *Ocean*.

To make so general a Restitution with Ease
and Expedition; it is to be considered, That al-
though (for Example) the Flood which arrives
at London-Bridge was rais'd the Day before, by the
effusion of the Sea at the *Equator*; yet ano-
ther Tide intervenes in the mean Time, between
these two Places, and happens every where alike

at *Twelve Hours* end, to supply the *Middle Stations*; and one Flood still succeeds another at the *same* distance of Time; as also an Ebb always intervenes between every *Two* Floods: Hence their *whole Course* of Ebbs and Floods naturally divides it self into *four Stages*, thro' which they pass with an *alternate Succession*, but with a *different Speed*, and after a *diverse Manner*.

They run their *first Stage* from the *Equator* to the *Center* of our *Atlantick* in *Six Hours* space, at the Rate of *five Hundred Leagues per Hour* (by way of *Libration*); and make their respective *Returns* in as many: The *second Stage*, from the said *Center* into the *Chops* of our *Channel*, in *Six* also, at the Rate of about *one Hundred Leagues per Hour*, (by *Undulation*;) The *Third* from their entrance into our *Channel*, to the *Streight* between *Dover* and *Calais*, (by *Fluctuation*,) only *Fifty Leagues per Hour*: And their *Last* from that *Streight* up the *River of Thames* (by a *protrusive Fluxion*,) no more than *Ten*: And the *Higher* they go, the *less* haste they make to the final Period of their *Course*; till at last their *Pace* growing *so slow*, and their *Six Hours Allowance* for their *Interchange* continuing still the *same*; the *Tides* come up *so close*, one on the back of another, that *Two* are sometimes found at once within the *same River*: Thus, by a *perpetual Reciprocation*, every Flood having its succeeding Ebb to devolve it back again; each supplying its proportionate Part, in *due Order*; the Performance is every where at once render'd compleat.

Lastly, Concerning the Diffusion of the above-said Tumour into the *South*; as much of it as tends directly towards that Point is soon put

to a Stop by the *Axe* of its *Libration*: But upon its *Déclination* to the *Westward*, towards the *Cari-
bbee* and *Antilla* Islands, this *secondary Tide* lan-
guisheth away almost into *Calm-Water* before
it reacheth the *Primary Flood*, at so remote a
distance from the *Center* of its *Diffusion*: Whereas
to the *Eastward*, the *Flood* falling upon the *Coast*
of *Africk* (which is not so far off) too obliquely
to be repuls'd towards the *Northwest Tumour*,
whence it came; it is deflected into the *Souib*,
and becomes a *Coasting Current* towards the *Equa-
tor*: And such like *Currents* attend the *Shores* of
the *Indian*, *Ethiopicke*, and *Pacificke Oceans*; and
doubtless, they proceed from the like *Tumour*:
So that, having already discover'd their com-
mon *Origin*, let us see how they are propaga-
ted, in the following *Section*:

S E C T. VII.

*How it comes to pass, that the Coasting Currents
of the Ocean, which rise beyond the Tropicks,
constantly tend towards the Equator.*

THUS the *Tide* passeth from the *Equator*,
beyond the *Tropicks*, and repasseth back
again in the *Midst* of the *Ocean* in *Six Hours*
apiece, by an alternate *Libration*; where it has
free liberty to swell, and rowl at a greater *Raté*:
but what correspondent Returns of *Floods* and
Ebbs the *Coasting-Currents*, which proceed from
it, can make, by a *slow Progressive Pace*, up-
on their *shallow* and *narrow Bottoms*, is to be
farther accounted for; and their *Courses* are,
in due proportion; to be adjusted to each other,

that every Flux may have its Reflux on either part, of the same Kind, or else some *Equivalent*, whereby to make the Ocean's *Equilibrium* by Restitution.

Now, in regard the Flux of these *Coasting Streams*, still descends from a Higher to a lower Situation; they must continually alike *withdraw* themselves from the *Flowing* towards the *Ebbing-Water*; as long as the Sea's Expansion, *betwixt* those Streams, is continued to an equal Breadth; and each Two *counterpoising Currents* (in compliance with the Floods and Ebbs, from whence they spring) must alternately rise *highest* and fall *lowest* at the said respective *Ends* of their *Libration*; but so (by reason of their *slow Pace*) as neither to raise nor let fall the *Axe* of their *Mean Course*, from the *Level* of the Ocean: Their Fluxes and Refluxes *decaying gradually* into Calm Water, before they reach it; or else mutually so to affect each other, as to incline it *towards neither Part*.

But in case the *Gulphs*, on each Side whereof there is an *Intercourse* of those counterpoising Streams, be *wider* at the one End than at the other; those Two Currents which proceed from the greater Expansion, being *contracted* by the *inclining Shores*, on both Sides, must become more and more enliven'd, to flow *Faster*, and hold out *longer* than those *other* on the Counterpart; which, being as much *dilated*, become proportionably *weaker*, and consequently *less able* to countermand 'em back again. Inasmuch, that

1. The *Coasting Streams* of the *Ethiopick Ocean*, by receiving quicker Recruits of Water in the *South* (where the Sea is more *dilated*) by *Libration*,

bration from the Flux of the Tide thitherward, which is perform'd in *Six Hours*; than can possibly be return'd by their *slow* Progressive Reflux towards the *Equator*, where it is most contracted; besides, sharp'ning their *Force* still more and more by their Contraction; they *repel* the *Counter-coasting* Streams, which otherwise had occur'd and met 'em the half way; and become, on both Accounts, *perpetual* without any *Reciprocation*.

And, forasmuch as the Tidal *Libration* is chiefly caused by the *Meridional Impulse* of the Moon's Pressure, *driving* it directly towards the *Poles*, by her Presence; and *letting it fall* back again perpendicularly, upon the *Equator*, in her Absence; the Motion of the said *Coasting Streams* as depending thereon, must so strictly observe the same Course; that, upon any *Deflection* from the true *North* and *South*, caused by the *Obliquity* of their Shores, they must still be sharpen'd into *quicker* Currents, on the inclining Sides; whether they be driven towards the *East* or *West*, or happen in *North* or *South Latitude*, without exception.

2. Hence we find, that the *Coasting Current* of our *North Atlantick*, tends as directly *Southward* towards the *Equator*, from the Streight of *Gibraltar*, along the Coast of *Gualata*, to *Cape Blanco*, as the *Westerly* Inclination of the adjacent *African Shore* will permit; and keeps the incumbent *Trade-Wind* so close to the same *Southerly* Direction, as not to suffer it to exceed *Twenty-Eight Degrees* to the *Norward*, tho' its usual Limit be *Thirty Degrees* at least; and being repuls'd by the *Shore of Guiana*, it enlargeth it self again to *Thirty Two* or *Thirty Three*:

Which plainly demonstrates, that both the *Sea* and *Wind* are driven *athwart* their proper Course, or else the *Flux* of the *Former* had run true *South*; and the *Latter* had neither begun so near the *Equator*, nor had ended so far from it.

3. And to pass the *Line*, from the *Atlantic* to the *Ethiopick Ocean*, which lies extended *Piramidically*, with its *Vertex* pointing into the *North* towards the *Equator*; and its *Basis* subtending it on the *South*, from the *Cape of Good Hope* as far as the *Magellanick Streight*; whence the *Collateral Currents* (which at first move but slowly thro' that vast Extent), being contracted by the *inclining Shores*, mend their Pace (especially on the *American Side*, where the *Shore* is more inclined to the *Eastward*) up to the *Equator*; and thence they pass *Two Degrees* farther, till the *Tidal Tumour* out of the *North* come up to countermand them; and then their united Stream veres about gradually, from *West* to *East*, and carries the *Trade-Wind* headlong with it, quite contrary to its *Common Course*, for *Five Hundred Leagues* together.

4. And when we double the said *Cape*, to the *Eastward* of the *African Coast*, we meet with a *Current*, which follows the *Direction* of that *Shore*, from *Madagascar*, *North-Easterly*, beyond the *Line*, into the *Arabian Gulph*, which conducts the *Southwest-Monsoon* thither; and being deflected by the *Cambaian Shore*, turns the *Northwest-Monsoon*, according to its *Declination*, back with it, into the more *Easterly Part* of the *Indian Ocean*: And to the *Eastward* of *China*, and *Cambodia*, we find the *North* and *South Floods* hastening, from the *Pacifick* and *Indian Oceans*, towards their *Concourse* at the *Equator*.

5. Finally,

§. Finally, on the *Western-Shore* of *Peru*, a perpetual Flux of Stream follows the *Shore*, from beyond the *South Tropick* as far as the *Gulph of Panama*, up to the *Line* : (As also along the Coast of *Africk*, from the *Cape of Good Hope* to the *South Shore* of *Guinea*) for near a *Thousand Leagues* together : And, on the contrary, the like Flux of Water hasts to meet it there from the *North* at the same Rate, tho' with an *unequal* declivity of the *Shores* ; the *Wind* attending 'em respectively, upon the *same Points* ; which plainly shews, that the true *North* and *South* Points were chiefly aim'd at by 'em both ; and had been as strictly observ'd, had the *propension* of their *Shores* prov'd more favourable to their Natural Inclination.

So general is the *Confluence* of all the *Coasting Currents* of the Ocean, from all Sides towards the *Line* ; and so *irresistible* are their Courses thitherward, especially when their Channels grow more *contracted* that way : And to make as general a *Restitution* to those Seas, no more is required to keep their *circular Correspondence* on foot, than that, upon their arrival thither, they be ingulphed and *swallowed down* by the *Detumescency* of the Common Tide ; and be cast up again by its *Intumescency*, beyond the *Tropicks* whence they came ; that their Fluxes and Reflexes may be perpetually repeated, by an *Alternate Reciprocation*, for ever.

§.

Now, lest it may seem impossible, for the Tide to *swell up* Tumours upon the Ocean's Superficies, so *high*, as to let Streams *fall down*

from 'em, with a constant Descent, for Six, Seven, or Eight Hundred Leagues together ; and such as are the Currents which do Coast Guatara, and Congo in Africk ; and Peru in America : Or else, lest it shou'd appear no less practicable for any possible Impulse of the Sea to drive the said Stream progressively for so long a Course, upon the same Level with their adjacent Oceans, (which remain Calm and Stagnant all the while:) especially, their Channels being too Shallow and Narrow, for their Floods to be accelerated by Undulation or Libration ; as is manifest :

To clear these Doubts, it is remarkable ; that (all those Three Coasts lying open to the Ocean towards the West) the Trade Wind very opportunely supplies all those Defects, by descending down upon those Rills underneath, from their respective Eastern Shores ; which, by uniting its Streams of Air, with theirs of the Water, gives 'em Fall all along those Coasts ; especially the Wind moving also towards the Equator ; where the Air is lighter, and more expanded to receive it.

And, as for those Currents that Coast the opposite Shores, which the Trade-Wind confronts on the East of Brasile and Ethiopia, after it hath gather'd more Force in passing over the East Indian and West-Indian Oceans ; it is again remarkable, that it disputes every League of the Return of those Coasting Streams, towards the Equator ; and according to the several Seasons of the Year, takes their Advantage against each other's Courses, as well in the South Atlantick as the East-Indian Seas, while it blows on the South Side of the Line more Easterly, and on the North Side more Westerly ; but never to that degree,

degree, as to put an absolute Stop to that of the *Sea underneath*, towards the *Equator*.

And, if it appear less consistent with the *Laws of Motion*, than is practicable ; that these *Supplies* from the *Tide* shou'd be *Periodical*, and sometimes *Intermit* ; yet the dependent *Coasting Currents* flow *Progressively* the *same way*, to a *Perpetuity* : 'Tis no more than what constantly happens in the *Flux of the Veins*, in respect of the *Arteries*, in the *Bodies of Animals* ; and less to be wonder'd at in these *Currents of the Sea*, where fresh *Recruits* come in *Six-Hourly*, on the one *Part* ; and the *Course* which *evacuates* 'em on the other, reaches not its *Period*, with regard to any *determinate Part* of the *Water* which is mov'd, perhaps once in a *Month*.

Such is the *Tendence* of these scatter'd *Streams*, in the *Ethiopick*, *Indian*, and *Pacifick Oceans* ; and so conformable to those, which are found in our *North Atlantick* ; as to infer a thro'-out *Analogy* in the *Production*, and *Propagation* of the *Tide* itself in *all Places* ; so far at least, as each of 'em to *swell up* a distinct *Tumour*, about *Forty-five Degrees* on each *Side* of the *Equator* ; and to *diffuse* their *Effluvioms* after the *same manner*, into *all Seas and Rivers* thro'-out the *Universe* : Let us see how the *Main Bodies* of the *Ethiopick* and *Atlantick Floods* accost each other, at their *joint Return* to the *Equator* ; to draw the *Theory* of this *Deduction*, from a farther *Observation* of *Matter of Fact*.

S E C T. VIII.

Of the Concourse, and Result of the Ethiopick, and Atlantick Tides, at the Equator ; and the Irregularities which attend 'em in the Streight between Brasile and Guinea, Explain'd, and Reconcil'd.

TO shut up my precedent Discourse of the Motions of the *Tide* and *Wind*, as they fall precisely within the Precincts of the Ocean: And, as the Former takes its Rise from the *Moon's Pressure*, chiefly upon the *Equator* ; and rebounds back again Thither from the *Poles*, in six Hours a-piece ; It remains to determine *When*, and *How* those *Tides*, and *Winds*, which are peculiar to the aforesaid Oceans, severally affect that *Line* ; together with their respective *Consequences* ; which are as follow.

First, Concerning the *Tide*, it is to be Consider'd ; That the said Oceans, consisting of Two vast Bodies of Water, and lying Situate in different *Longitudes* ; the Regulation of their respective *Tides*, must be taken from their *Mid-Sea Tracts*, where they Move with most Freedom, and strictly observe the Course of the *Moon*, whereon they depend : And, by consequence, They cannot fall upon the *Equator*, at the Intersection of any One determinate *Meridian*, nor be Regulated by it ; but Each necessarily requires a distinct One, according to their different *Longitudes* ; as is Manifest.

Besides, That part of the Ocean, which lies more Easterly, must needs be so much sooner Influenced, by the Diurnal Course of the *Moon* ;
and

and its respective Tide, must *precede* the Other proportionably : Hence the *Ethiopick* Part, which lies more *Easterly* than the *Atlantick*, by near *thirty Degrees*, must Flood about *two Hours* sooner, upon the *Equator* ; and finding *Low-water* There, must pass beyond it to the *Norward*, all the while ; until the *Atlantick* Tide comes up, to *Countermand* It ; after it has transgress'd the *Line*, its proper Limit, at least *four* or *five Degrees* ; as is found by Observation.

Nor is any other *Parallel Line* assignable, for their *Opposite* Floods, immediately to Insult each other ; but rather their Counter-flux's must begin to *abate*, at a considerable *distance*, and *gradually* languish into a Calm, before they *approach* Each other ; and jointly *stagnate* for a Compass of Sea, *proportionate* to their vast Extent : As Our *North* and *South Tides* do, at their Congress on the Coast of *Suffolk*, which they becalm all along into a *Pool* : So do these Counter-floods of the *Ocean*, stagnate near the *Line* into Calm-water, as *Hydrographers* remark, from *four* to *ten Degrees* North Latitude ; without Assigning for it, either This, or any Other Cause.

Yet the *different Heights* of the said becalm'd Tumours, so little *correspond* to the several *Extents* of the Floods, which respectively raise 'em ; that, whereas Our *North* and *South Channel* swell *Humber*, at their Congress, at least *Ten Fathom* ; This, which is rais'd by the *Course* of the said *Oceans* (taking the Tide at *Cayen*, a Neighbouring Isle to the *Line*, for its Standard) Ordinarily exceeds not *six Foot*, nor superadds Extraordinarily above *six Inches* ; in regard the *Ethiopick* Flood, having pass'd thro' the

the *Streight*, to the *Norward* of the *Equator*, its proper Limit; and *spent it self* by its Expansion, before their Congress; it cannot advance its Stream higher: And afterwards (by its *two Hours Ebb*, before the *Atlantick* makes High-water,) it *takes off* as much from the Flux of that Tide, as it *Advanceth*; and so keeps their joint Tumour to the same Height, without any perceptible Addition, for *near three Hours* Space.

Moreover, in regard the said Tides, being driven Originally by the Moon's Pressure, at *equal Angles* from the *Equator*, True North and South; they shou'd have *recurr'd Perpendicularly* upon It, at their Congress; Yet (thro' the different *Figure*, as well as *Situation* of the said Oceans,) They occur to Each other very *Obliquely*; the *Atlantick Flood*, being deflected *Westward* by the *African Coast*, from the *Streight of Gibraltar*, as far as *C. Verde*; And the *Ethiopic*, being contrary-wise devolv'd from the *Brasilian Shore*, to the *Eastward*, with greater Precipitation, upon the Tumour aforesaid; which, lying *Eastward* from the *First Meridian*, still, more and more, inclines its Course *Easterly*; till at last it fetches the South Coast of *Guinea*, which deflects it Thitherward, for *five hundred Leagues* together.

Secondly, Touching the *Winds*, which accompany the said *Streams*, neither Matter, nor Disposition for 'em, can be wanting in this Juncture; the *Air*, throughout the *Torrid Zone*, being extremely *Rarify'd*, by the Heat of the Sun's Reflection, below; and *Condens'd* as much by the excessive Cold of the Upper Region, above; as plainly appears, by the frequent and violent

violent Falling of *Hurricanes*, near the *Equator*; and that also *Perpendicularly*; which are converted into as Violent and impetuous a *Wind*; wanting only an *Horizontal Determination*; which They receive *Effectually* from the supporting Streams of Salt-water; whose Current is *swift, perpetual*, and of a considerable *Extent*.

Hence the *Trade-wind*, which of Course blows *North-East* from *C. Verde*, on the *Atlantic* side, and shou'd begin *low*, and increase *gradually*: On the contrary, it *presently* becomes very Brisk; being *enliven'd* by the Breeze of the *Coasting Current*, underneath; which *deflects* its Course, according to the *Inclination* of that Shore, a Point or two more *Norwardly*; And withal, confines it to *Twenty-eight Degrees* of that Latitude, instead of allowing it *Thirty Degrees*, its *Usual* stint: But afterwards, leaving it *farther off* at Sea, lets the Wind *fall again* by degrees, before it reacheth the *Caribees*: Both which, observing the *In's* and *Out's* of the *Guianean Shore*, and following the Conduct of its *Norward* Tendency, re-advance at last to *Thirty-two*, or *Thirty-three Degrees*, as it were by *Rebound*.

Thus the *Trade-Wind*, and the *Sea-Breeze*, easily comply with Each other, for a Point or two, in a *Calm* and *expanded Ocean*: But, to the contrary, on the *Ethiopick* side, where their *Flux's* are directly *Oppos'd* to each Other, the *Sea-Wind* must receive a *stronger* determination from the substrate *Current*; and so be inclin'd more to the *Eastward*, by the *Brazilian Shore*; and re-enforc'd by that *contracted* Sea, to conserve and *hasten* their Motion; the Current

rent of *Water*, underneath, still drawing the Incumbent *Air*, Forward; which, as it were, opening a *Channel* in the Sky, for That of the Upper Region to rush down after it, Both jointly push the Stream forward, by their Fall; Each still mutually exciting the other's Motion; till the Eastern Shore of *Ethiopia* at once puts a stop to their joint Career.

Such is the Concourse of the *Ethiopic* and *Atlantick* Floods, both of Wind and Water, near the Line: Now, to bring 'em off again by way of Result, so that their Streams may make *Restitution* to the Air's, and Sea's *Equilibrium*, by returning whence they came:

First, As to the *Main Bodies* of these Two Counter-Tides; as their *Intumescency* had brought 'em on to their Congress, each in the Space of six Hours; so the *Detumescency* of their Floods, serves now to take 'em off again, Backward and Forward, in equal Spaces of Time, by *Counter-Libration*; without making any Commotion in the *Air*, that is *Progressive*. And,

Secondly, As for those *By-streams* of Water, which issue *Progressively* from 'em, and are apt to produce the like *Currents* in the *Air*; They mutually propagate *Each other*, and jointly live, and die together; as happens in That Stream of *Water*, and *Wind* conjoin'd; Which, taking its Rise at *C. Verde*, and passing along *Guiana*, to the *Caribee-Islands*, conveys Them thence around within the *Bay of Mexico*, till they diffuse themselves again, from the *Bahamaan Streights* into the *Ocean*; where they separate into distinct *Currents* of Water, and Wind; but are still of the same *Westerly Determination*.

And,

And, as for That Stream of *Water*, and Flux of *Wind*, which makes so much haste through the said *Streight*, from the *West of Brasile*, to the *East of Guinea*; As to the *Watry part of it* (finding no other Vent nor Retreat) it sinks *Sea-ward* all the while; and parts with what's superfluous, and exuberant, into the Ebbing Tide, to carry it off by *Libration*; while the Super-incumbent *Wind*, which was dense and heavy before its Fall, goes on *Rarifying* again into *Common Air*, by the excessive Heat of the Sun; till it be incorporated with the *South-East Trade-wind*, (and so 'tis return'd back again, whence it came); which *never fails* to Blow, at *two Degrees* on the *South* of the *Equator*; as receiving so constant a Supply; nor *varies* There, as in *Other Seas*, from so steady a Determination.

Thus are the Concourse and Result, of the *Ethiopick* and *Atlantick Tides*, adjusted; forasmuch as they consist of *Motion*: But, how they Occasion the Intervening *Calm*, requires to be farther Explain'd, in the ensuing *Section*.

S E C T. IX.

How the Calm in the said Streight, is Occasion'd; and differs from those, which happen in other Seas.

HAVING already reconcil'd all Appearances of *Irregularity*, in the Motions of Wind or Tide, which are apprehended to be in the said *Streight*, to the *general Rules* already prescribed 'em, by Those who have Treated on that

that Subject : It may seem vain and superfluous, to search after Reasons for their Opposite Calms ; since all Solid Bodies naturally require Rest ; and Fluid ones too as constantly propend towards it, all Obstacles being Remov'd.

Yet, in regard a due *Examen* of One Contrary often serves to *explain* Another ; and the restless Courses of the *Sun* and *Moon*, draw the Fluidity of *Air* and *Water*, into an *endless Distraction* of contrary Motions ; and these volatile Elements lie so *close together*, that the One can scarce be *stirr'd*, without *disquieting* the Other ; *absolute Calms* can hardly be found, either by *Sea* or *Land* ; and even Those that are perceptible to *Sense*, are not so easily reduc'd to their *proper Causes*, as not to force *Us*, for their *Existence*, *Continuance*, and *Extent*, to have recourse to their different Circumstances.

Concerning those Calms, which fall not within the Compass of the *Trade-wind* ; the Motion of the *Air* is every-where, both at *Sea* and *Land*, so *various* and inconstant, that no *proper Seat*, nor *Sea*, can be Assign'd for 'em : And more particularly, the Surface of the *Ocean* is so Obnoxious to be *ruff'd* with every Blast of Wind, that no *Calm* can happen There, but by *Accident* ; viz. that *Both* their Flux's acquiesce *at once* ; which can hardly be farther Accounted for : And, as to Those that happen *between the Tropicks*, they are seldom found in any *Open Sea*, where there is either Flux of Wind, or Water, to *disturb* their Tranquility ; and that mostly, when the Course of the *Sun* is *vertical* ; so as to raise the *Air*, and let it fall again *Perpendicularly*, in the same Place.

So that those *Calms*, which fall, as it were, of course, and are remarkable for Time, or Place; some are shelter'd in the *Bays* and *Creeks*, where they happen, by the adjacent *Coasts*, from all Commotions of either kind; their *Heights breaking* those Blasts of Wind, and *Forelands carrying off* those Streams of Water, *Seawards*, from one *Cape* to another, which wou'd otherwise disquiet 'em; as it chanceth in that Elbow of the Sea, on the *Coast of Peru*, where *Calms* and *Hurricanes* are often found; the *Andes* sheltering 'em on the *East*, from the *Trade-wind*; and the *South* and *North Capes* keeping off the *Currents*, which pass by the interjacent *Bays* inoffensively, from the one End of 'em to the other.

The like *Calms*, and *Hurricanes*, are found on the *South-East Coast* of *Africk*, in a *Bay* at the Entrance of the *Coasting-Current*, from the *Indian Sea* into the *Arabian Gulph*; which, according to the *South-west Direction* of its Channel, passeth along thither; while the *Isle of Madagascar* shelters it from the Insults of the *South-East Trade-Wind*; the like Harbour is found for 'em, on the *Eastern Coast* of *Coromandel*, when the *South-East Monsoon* ceaseth to disturb the *Gulph of Bengal*; and a long *Ridge of Hills* protects it on the *South-West* from the Tide, which is warded off all the while.

In other Seas, the Tranquility of the Air is secured from any irregular or hasty Commotion of the Tide, by the Constipation of many *Islands* pitch'd thick together, to hold their Superficies steady; as are those, on the *South-East of China*; which, being interspers'd

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with

with the *Philippine* and *Molucca* Islands, infested by *Hurricanes*, upon the break of the *Monsoons* into Calms, as to be navigable: As also the *Caribees* in the West, where the Tides are weak; when the *East Trade-wind* chanceth to cease, and the *South-east* Wind, which is the *Trade-wind*, is so weak, as to be almost uninhabitable.

Yet such furious *Storms*, which seem peculiar to these *Isles*, and so dreadfully afflict chiefly in *August*, when the *Sun* is at the *Equator*, are of no long Continuance, or great or *Anniversary*: Some *Years* having more than one, and sometimes for several together, as *Dr. Halley* remarks, none. Whereas the *Tract* of *Sea* before-mentioned has no *Trade-wind*, nor a variable; but is to be condemn'd to perpetual Calms, with terrible *Thunder* and *Lightning*; frequent, as to be call'd *The Sea of Rages*; has neither any such adjoining *Coast* to support it; nor *Islands* to support its Quiet, nor require in other Seas.

But, as the joint Concurrence of the *Pacific* and *Atlantic* Floods (as I have shew'd in the last Section) conspire to fix that *Tract* of *Water*, fix'd; so their constant *Currents* of *Wind*, suffice to form other contrary *Motions*, from another *Air's* Tranquility, for all that Space. I extend this Remark to the *Pacific* also, where the *North* and *South* Tides have Season enough, to insult each other at their concurrence upon the *Equator*, all along from *China*, for two thousand Leagues; yet they preserve the same Tranquility of *Air*, and *Water*, for four or five De-

side the *Line*; notwithstanding the *Counter-ches* of the *South* and *North-East Trade*, as *Hydrographers* describe, and *Navigators* by Experience; who, sailing *West* from *Peru* to *China*, bear off their courses on each Side of the *Line*, at least six degrees, to take the said Winds at their advantage.

manifest it is made, by the former Section *regularities reconcil'd*—, that the proper genuine Motion of the Tide, is true and *South*, without any Deflection to-*East*, or *West*; save what's occasion'd by *curving Coasts*, or *Channels*, of a different direction: And that the *Eastern Trade-wind* is naturally bent to distract it, with all its *North-easterly Variations*; the depending chiefly on the *Meridional Pressure* of the *Moon*; and the latter on the *Air's Motion*, pursuant to the Diurnal Course of the *Earth*: And it is finally made remarkable, that of *Occasional Calms*—, that those of *Sea*, wherein these *Calms* reside, are only *Elbows* of the *Wind*; or at least lie little obnoxious to disturbance, from the two Motions of the *Tide* and *Wind* afore said.



C H A P. III.

How the Tide is propagated, and spread over our Western Ocean; with special Regard to Time and Place.



INCE I have hitherto only occasionally disclos'd the Nature of the Tide, and its Production; in the former Chapter, with regard to Time, and in the latter as to Place, thro'out the Ocean; without insisting farther on either of those Circumstances, than to draw the *Instances*, so remark'd, into one continued Series of Discourse, by way of *Cause* and *Effect*: In order to evince the Sun and Moon, to be the sole *efficient Causes* of the Tide; and their Pressure the *instrumental Means*, whereby it is effected: And this upon the Attestation of the daily *Experience*, and constant *Observation* of *Navigators*; as far as their *Senses* cou'd inform 'em, and their *Words* express it.

But as to the *Manner*, how this great Work is perform'd, especially in our *Western Ocean*, which is best known to us; and why it is propagated by *Libration* in the *Ethiopick Part*, and spread over the *Atlantick* by *Undulation* (which are caused alternately by their *Presence*, and *Absence*;) hence I design the Place where the Water makes, by the common *Lines of the Sphere*; and chiefly with Regard

gard to the *New* and *Full-Moon* Tides, which jointly observe the same Solar and Lunar Hours, and are those whereon the rest depend.

And to express the Time, *when* the Water is so affected; the *Horological* Characters I, V, X, are inserted in the *Squares* within the said *Lines*, to shew its Terms and Periods of Time; while the *Darts* interspers'd among 'em, point out their *Tendence*; and this also by a *Map*, to shew their Distances, and Bearings, as to Place; that all may be render'd at one View, as visible to the *Eye*, as it is perceptible by the *Understanding*: And first, by a Draught of the *Sea in general*; to shew the Natural Constitution of the Tide, in its greatest Amplitude; and afterwards by more particular ones, to exhibit its Application to their several Divisions, after a more special Manner.

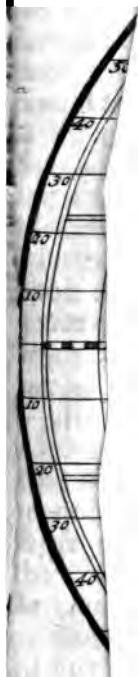
S E C T. I.

Of the Application of the Tide to the Globe in General; with regard to the principal Lines of the Sphere.

Notwithstanding our Terrestrial Globe were universally surfac'd with Water; yet, nevertheless, it wou'd stoop as low in the Moon's Presence, and rebound again as high at her Absence, upon any determinate Point, between the Tropicks (where her Pressure is most intense) as it does at present: And consequently, there must be High-water *where*



Population growth is a major factor in the development of the world. The number of people in the world is increasing rapidly, and this is leading to a number of problems. One of the main problems is the shortage of resources. As the population grows, the demand for food, water, and other resources increases. This can lead to a shortage of these resources, which can have a negative impact on the environment and the quality of life. Another problem is the increase in pollution. As the population grows, the amount of waste and pollution produced also increases. This can lead to a number of health problems and environmental damage. Finally, population growth can lead to a number of social problems, such as overcrowding and poverty. As the population grows, the demand for housing and other services increases, which can lead to overcrowding and poverty. This can have a negative impact on the quality of life and the environment.



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ting of the Tides to the *Norward*: which, being propagated by *Undulation*, make no remarkable Returns; their wavy Billows, either reaching the *Poles* themselves; or else *subsiding* at last into smooth Water, suppress'd by their own Weight.

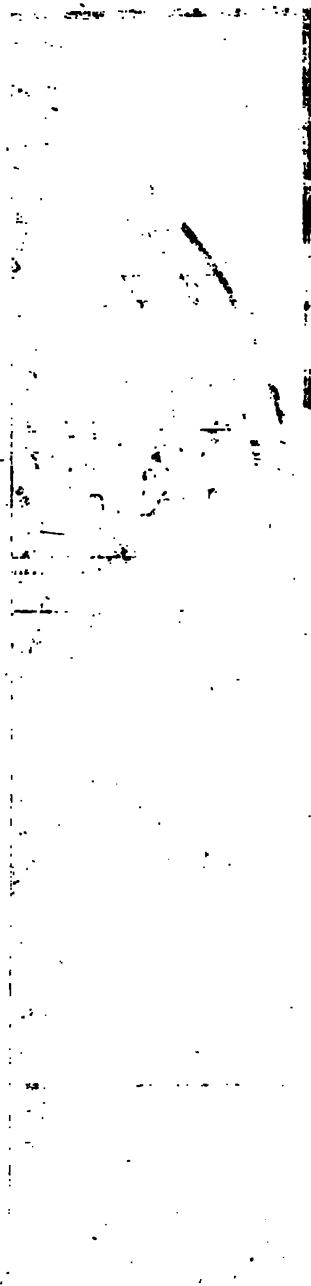
Such is the *Theory* of the *Course*, and Constitution of the Tide, as described by the *Lines* of the *Sphere*, upon a *boundless Ocean*: Now, to apply the same to practise upon the *Sea*, as it lies actually *confined* by the *Coasts*, and *Shores*, of our terraqueous *Globe*; that what *Speculation* has already propos'd in general, as most agreeable to Reason, may be found by *Experience*, to be Matter of Fact; in the *Places* most concern'd, thro'out the *Universe*; I begin with the Display

S E C T. II.

Of the Tide's Application to our Western Ocean; with a special Regard to the Ethiopick Division.

TO descend from the Consideration of the *Sea in general*; to the farther Inspection of our *Western Ocean*, in particular; with reference to the Tide's Reception, it lies extended from the *Artick*, to the *Antartick Polar-Circle*; divided into *two Seas*, with an open and free Passage betwixt 'em, for the Intercourse of its Floods out of both *Norh* and *South Latitudes*: And to enter, in the first Place,





Place, upon the Survey of the *Ethiopick* Part, whose Figure is pretty *Regular*, and Situation more *Oriental*; it is observable, that its *Eastern* Shore lies *North* and *South*, from near the Height of *Benin*, to the *Cape of Good Hope*, for *forty Degrees* together; to give the *Morning Flood* its proper Direction:

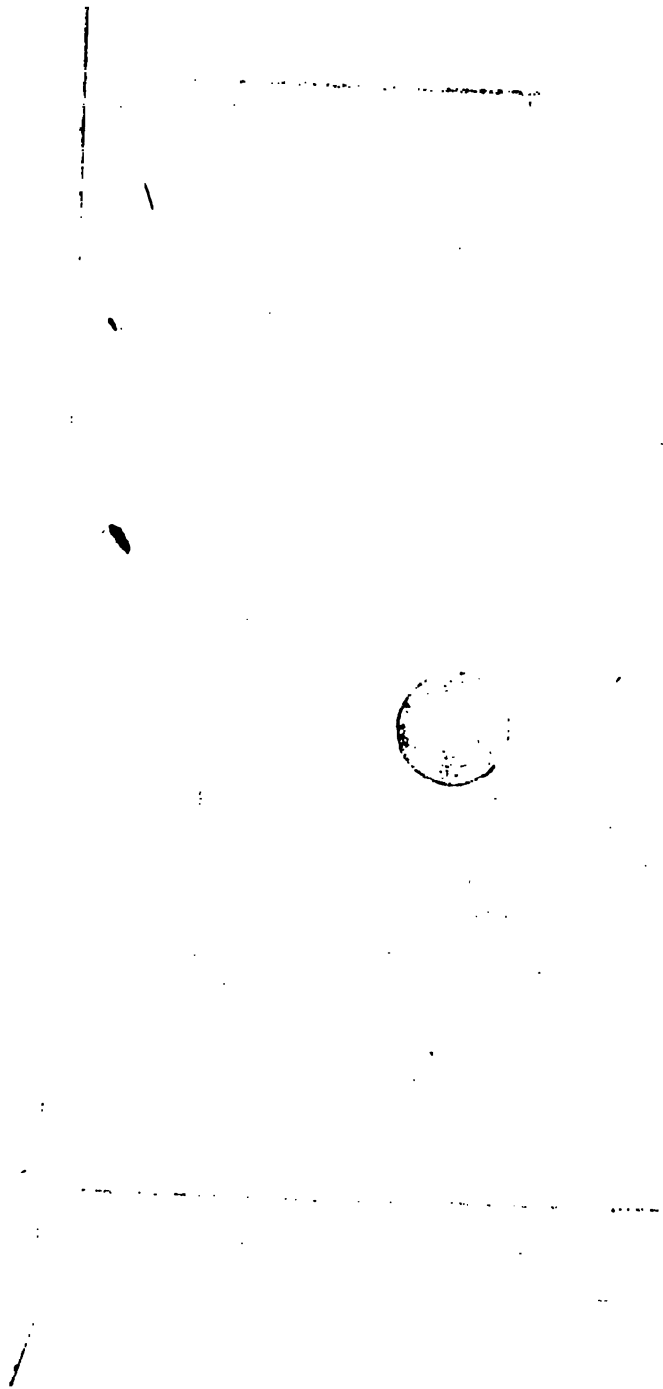
And withal, to serve for a Pattern, to draw the more *Westerly* Lines of the Tide's *Libration*, Parallel to itself; and with a singular *Uniformity* amongst themselves (conformable to that which is already described in the *general Map* of the *Globe*); and so *close* to each other, thro'out that Sea, to the *Eastern Coast* of *Brazil*; as to carry the Succession of the Tides, *thitherward*, Line by Line, concomitantly to the Diurnal Motion of the Moon, from her Rising towards her Setting; as far as the Breadth of that Sea extends; while the *South Coast* of *Guinea*, which stretcheth itself forward from *East* to *West*, along the *Northern Shore* of this Sea's Division, serves for a *Scale*, to remark the *Hours* and *Minutes* of their Concomitancy, for *five hundred Leagues* to the *Westward*: Let us consult the *Pilot's Observation*, upon this Point; and take his Word, illustrated with a *Map* that's drawn according to his own Direction, for an undeniable Principle.

To begin the said *Series* of Floods, at the *Easternmost* Part of the Gulph, the *English Pilot* for *Guinea*, assures Us; "That at *R. Gabon*,
" upon the *Equinoctial Line*, an *East* and by
" *North Moon* makes High-water, at $V\frac{1}{2}$;
" and at *R. Danger*, an *Easterly* does the same,
" about

" about VI: At *Monamba's Hole*, an *East*,
 " and an *East* by *S. Moon*, at VI, and VI $\frac{1}{2}$;
 " At *Bato*, and *Cameroon*, an *East*, at VI: So
 " at *R. Rey*, does an *East*, and an *East* by
 " *South Moon*, at VI, and VI $\frac{1}{2}$; At *Benin*,
 " an *Easterly Moon* fills all full, at VI; and
 " at *Caran*, an *East*, and *East* by *S. one*, at
 " VI, and VI $\frac{1}{2}$; and passing along the same
 " Coast to *Gojaven*, a *North-East* by *E. and*
 " an *East N. E. Moon* makes the Water flow
 " there, at III $\frac{1}{2}$, and IV $\frac{1}{2}$: And a little farther
 " at *Swine*, an *E. Moon* swells the Water,
 " at VI: And following the Shore to
 " the utmost *West*, at *R. Serbera*, the Water
 " flows with an *East* by *South Moon*, at VI $\frac{1}{2}$:
 So close does the *Westward Motion* of the
 Tide, stick to her *Diurnal Course* all the while,
 for five hundred Leagues together.

Now, to demonstrate that the Tide follows her said Course, to the *Westward* as close, both for *Succession* of Time, and Height of Water, and flows as constantly at XII, upon the Parallel of 45 Deg. *S. Latitude*; as it doth upon the *Equator* near VI, along the Coast of *Guinea*.

First, As to the Account of Time; the Water flows, on Change-days, at *Port Desire*, in 27 Deg. *S. Latitude*, upon the *West American Shore*, exactly at XII, the Moon being vertical; and, *Secondly*, As for Height of Flood at 51 Deg. *S. Latitude*, it is not wanting in the *R. Gallegor*, upon the same Shore, (which riseth and falleth 60 Feet.) to equalize ours on the *Western Coasts* of *Europe*, at the same Deg. of *N. Latitude*: Without the Concurrence of the *inclining Shores*, and *shallow Bottoms*, very fre-



quent in our narrow Seas; and so may be for a Standard both of Time and Tide, from the said American Shores, from 47 Deg. 30 Deg. S. Latitude, that is, from C. Blanco Horn; the various Ins and Outs of the Bay's Declivity, being consider'd.

And if it be objected, that, in the Mouth of Magellanick Streight (which lies but one Degree from that River, and scarce 4 Deg. from the said Port) the Flood riseth not half so high as at the one, and yet makes High-water by an Hour, than at the other: It is replied, that the Streight is flooded there irregularly in both respects: For,

As to the former, viz. That it riseth 10 Fathom instead of 10, as in the said Bay, which is the Entrance into the said Streight, contracting its Sides towards the Bottom, into a narrow Gullet, opens itself into a second Bay, of an equal Extent: In the Flood, by its passing thro' it out of the one into the other, loseth half of its Height in the former; and repassing it, keeps up its Height as much, by way of Restitution; especially being swell'd by the Occourse of the Streight's strong Current, from the East; the Tide of Flood and Ebb, running so strong both ways, equally, as not to be stemm'd; tho' scarce discern'd in the Streight's Mouth, which is fix'd all the while, within the Com- of 4 Fathom; as being the Mean betwixt the two Gallego's Extremes, which it never leaveth.

And, Forasmuch as the Streight receives the Tide in ample Manner, with an open Bay, which is rais'd proportionatly with its Stream, which

The Tide's Course delineated,

which goes on *decaying* 'till High-water: Whereas its Current, being *strained* by the said Gullet, goes *increasing* all the while; the latter must needs take off the *Top* of the former, at least *an Hour* sooner than ordinary: Hence it comes to pass; that, as the Tide in the *Streights's Mouth*, neither *swell'd* so high, nor sunk so low as in the *River Gallegos*; and withal *surceaseth* to rise, before it does so at *Port Desire*; yet, at all three Places, the joint Tidal Supplies were added and withdrawn, at the same respective *Instants*, and also in equal Measure.

After all, since the abovesaid Tide at *Gabon*, neither issued out of the *East*, whence no *Sea* nor *Gulph* cou'd be found to supply it; nor was it brought along by the Current from the *Westward*, which directly *opposed* its Course; much less was it favour'd by the *Atlantic* Flood out of the *North*, which bore up strongly *against* it; but was wholly supply'd by the *Ethiopick* Tract of Sea, which lay open to the *South*. And in regard the Tide between the Latitude of *Port Desire*, and the *River Gallegos*, most abounds with Water, and at XII, when the Tide at *Gabon* wants it at VI, and on the *Converse*; hence the one must needs *supply* the other; and both Tracts must be equally co-extended *East* and *West*, to do it *successively*, according to the *Diurnal Conduct* of the Moon, already described.

And their mutual Correspondence is kept on Foot by *Libration*; as plainly appears by the *Counterpoising* Tumours, at each End of the *Balance*; the one near the *Magellanick Streights*, which is vast for *Height*; and the other

other upon the said *South-Guinean Coast*, which is as formidable for *Speed* and *Force*: While at *St. Helen's*, near its *Axe*, the Surface of the Water riseth or falleth scarce a Foot: Each furnishing the other with new Recruits of Stream, and fetching 'em off again alternately, without Intermiffion.

Thus the Tidal Tumour swells with the rising Moon, and sinks again in the *Ethiopick* Tract of Sea, with her *Southing* Pressure upon the *Equator*; and the *Lines* of its alternate Approach thereto, and Recess from it, lying Parallel to the *Eastern Coast* (which gave 'em their first Direction) fall Perpendicularly upon that Line, with the same Uniformity, that I have already described, in the *Universal Map* of the Globe; while the Moon, pursuant to her Diurnal Motion from East to West, successively depresseth the Water's Superficies, within the Tropicks; to raise it again by *Libration*, beyond 'em, at the very same Instant; that, what she expels by her Pressure, from the one Side; may be fetch'd back again from the other, by its own Weight, with an alternate Reciprocation.

So fitly, in every respect, doth the regular Appearance of the *Ethiopick Flood*, fall in (for an Example) to establish the Preliminary Account already given of it, in the Description of the *Sphere in general*; nor will the manifold Anomaly of the *Atlantick Tides*, when duly consider'd, more prejudice the Validity of that General Rule, by way of Exception; than the Conditional Proviso's, do the Obligation of a Bond; but, on the contrary,

trary, serve both to *explain*, and *enforce* it;
Let us try the Experiment.

S E C T. III.

Why the Atlantick Flood is not devolv'd diurnally to the Westward, like the Ethiopick; but makes full Sea from East to West, at the same Instant.

WHEREAS the Lines of the Tide's Libration, lie so uniformly extended North and South, on the Ethiopick Side of the Equinoctial Line, as I have declared, to give its Floods, and Ebbs, a suitable Reciprocation; on the contrary, the Atlantick Division of our Western Ocean, being neither of a Rectilinear Figure, to give 'em any special Direction; nor of a regular Shape, to conform 'em suitably each to other; all the said Lines, are confusedly involv'd into one; and that also, becomes as variously deflected either to the East, or Westward, according to the Declivity of its Shores; Cape Verde, and its adjacent Islands, giving that Atlantick Flood, at its first Appearance, a Westerly Turn towards the Caribbees, for at least twenty Degrees; which the Coasts of Florida, Virginia, &c. up to Newfoundland, as briskly return full thirty Degrees again to the Eastward; and it is still devolv'd from both Sides, into the Middle Channel, where it rowls with most Freedom, and must flow all at once, as it were, with one single Motion.

Beside,

Besides, the Bluntness of the *Moon's Atmosphere*, universally affecting the *whole Surface* of that *Atlantick Tract* of Sea, between the *Tropicks* (as it were a *Lake*), without any considerable difference of Pressure; the ponderous *Self-coherence* of the Water, so generally affected at once, cannot successively resent the Impression, with any sensible Distinction; and consequently its Superficies must fall or rise together, co-extensively from East and West; from the *African*, to the *American Shore*; that is, from the one End of its Tidal *Axe*, to the other; as it plainly appears to do, by Matter of Fact. For,

As at *Cape Bajador*, at the East End of it, on the *African Side*; the Water flows with a *S. Moon*, exactly at XII; so also at *Carolina*, in the West, on the opposite *American Coast*, it swells with an *E. S. E. Moon*, at VII $\frac{1}{2}$; being distant from each other seventy Degrees in Longitude; which corresponds to four Hours and an half of Time, upon the *Horoscope*; which being added to VII $\frac{1}{2}$, makes the Number XII compleat, for the Water to flow, at the two so far distant Places, just at the same Moment.

Again, Since the said *Librative Motion* strictly requires, that the counterposing Arms of the *Balance*, be dispos'd jointly the one to ascend, and the other to descend at the same Instant; and consequently each of 'em, according to all and every Part, at whatever Distance from the *Axe*, must attain at once to its utmost Height, or Depth respectively: So must the *Atlantick Tide* acquire its Summits of Flood, or Ebb, at the same Time, at all Distances of

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Latitude from its *Northern Tropic*, to *forty-five Degrees* of Latitude; and as far towards the *East* and *West*, as its *Libration* extends: As it actually happens, at *Gay-Head* in *New-England*; where the Moon, at *S. E. by E.* make *High-water* at $\text{VIII} \frac{1}{4}$; being distant from *Carolina* *fifteen Degrees N. Latitude*, and about *eleven Degrees* in *Longitude*, which corresponds to $\frac{1}{4}$ of an *Hour*; which, being added to the $\text{VII} \frac{1}{2}$ at *Carolina*, adjusts the Account of the Tide at *Gay-Head*, at $\text{VIII} \frac{1}{2}$, to an *Instant*; without any Consideration had to the Distance in Latitude at all.

Moreover, forasmuch as the Moon's Pressure, affects the whole Space of the *Atlantic*, between the *Equator* and the *Tropic*, co-extensively from *South* to *North*, as well as from *East* to *West*; and with that Conformity, as to raise the Tide by *Contraposition*, at all the three Places above-mentioned, at the same Instant, tho' at so great a Distance from each other, both for *Longitude*, and *Latitude*: Hence the Tide so rais'd, to answer the Pressure's Extension, must affect, with the same Regularity in every respect, not only the so far distant Places, and the Lines of Distance between 'em; but also the Area design'd thereby, and contain'd therein: That is, the whole Body of the said Water, between the *Tropic*, and the Parallel of *forty five*; from the *African Shore* to the *American Coast*, so as to swell it all at once, according to its whole Extent.

And, if it be objected; That a *Southing* Moon makes a regular Tide, upon the Center of the *Atlantic*, at XII ; as being directly

counterpos'd to her Noon-stead Pressure, between the Tropicks, at VI; an Hour later, than at the three Places above-mentioned; as appears by the Tide at C. Bajador, which also makes with a Southing Moon, fifteen Degrees more to the Eastward, an Hour sooner than it; and consequently so much sooner than its other two contemporary Floods at Carolina, and Gay-Head: It is reply'd, that the Tidal Tumour is rais'd over-hastily, at all those three Places at once, by a preposterous Check: First, at C. Bajador, by the inclining Shores of the Canary Islands, compressing its Stream on the one Side, and of the Continent, on the other: The like is done by the Carolina Coast, in Opposition to the Bahamean Bank; which, opening wide to receive the Stream, contracts it to a Point in the Mouth of the Gulph of Florida; whose Current drives the Flood with so much Precipitation against the Shore, that it makes at VII½ a full Hour sooner, than in Ashley R. tho' upon the same Coast, and not above two Degrees distant from it. Lastly, the Promontory of Gay-Head (as C. Palmas at the Entrance of the R. Gojaven) hasteneth the Flood as much sooner, than it makes in the Virginian Sea, whence it sets; or, than in the Gulph along New-England, which receives it.

So exact is the Conformity of the said Primary Tides, with each other, between the Tropick and the Parallel aforesaid; and (abstracting from the Impediments of Coasts and Shores) with the Central XII, which, in the Middle of the Atlantick, has free Liberty to swell and sink at regular Hours, without any Disorder; and so well prepar'd is the Plan of

the Libration of the Primary one.

NOtwithstanding the Co-extension of the Moon's Pressure, to all that Tides of the *Atlantick* already described; so as that the *Primary Tide* to itself, thro'out the Extent of Sea, to the *same Instant*, for every Nature of its *Libration*; yet, as Part of the same Tidal Wave, which is closest to the Sea's *Central Meridian*, wrows in *deepest Water*, and flows in the *restest Channel*, from the *Tropick*, its *Axe*, towards the *Pole*; it must ne be *higher* than the rest of the Ocean: I farther this Flood passeth *beyond* its more it must be *advanced*, even to the Limit of its Lift, at the Parallel of *forty grees* Latitude; at an equal Distance from the *Equator*, whence it was forced: A upon its Return thither, it *sinks* again, depress'd by its *own Weight*; and round its Apex. by *Result*. (as a Stone

mark'd in the Map with XII; where the
Central Meridian of the said Sea, intersects

Parallel of *forty-five Degrees* Latitude,
thence its *Transfusion* is made: And the other
to be extended *Eastward*, to the Promonto-
ry of *Europe*; as for Instance, to *C. Finister*
Spain; and turn'd thence *Westward*, to the
Islands of *America*, to *Monomy Point* in *New-*
land: Whence it will plainly appear;
their opposite Shores lie at about *sixty De-*
grees of Longitude from each other, as to
the Moon; and allowing the Diurnal Course of
the Moon *fifteen Degrees*, for an *Hour*, they
are at *four Hours* Distance, of *Time*; which is
the accounted the *Diameter* of its Circu-
lar Sphere of its Activity, within the interja-
cean Ocean.

And, forasmuch as the Moon cannot reach
the said Central Meridian, to make High-water
at Central Noon, *stead XII*, 'till she has
pass'd the *European* Promontories *thirty De-*
grees, or *two Hours*, after her *Southing* at
Finister: And passing forward *fifteen Degrees*
thence, to the *Westward* of the said Meridian,
she has High-water at the *third Hour* after her
being at the Places aforesaid; that is to
say, at *III* in the *Afternoon*; according to
Observation: Hence it is manifest, that while
she advances forward *Westerly*, *fifteen Degrees*,
in one *Hour*, upon the *Horoscope*; the Tide
seth itself back again to the *Eastward*, *thir-*
ty Degrees upon the *Globe*, as far as *C. Finister*.
Now, in regard *Monomy Point* lies to the
Westward of the said Central Line, as *C. Finister*
to the *Eastward* thereof; and both at
thirty Degrees, in Longitude, distance from it;

The Tide's Course delineated,

So that the Moon, at once, appears at the former Place, at X in the Morning; and at the later, at II Afternoon; and when she Culminates upon the Central XII, as lying *Equidistant* from 'em both, and being the Point from whence the Tide *diffuseth* itself, towards both Places with *equal* Speed; and consequently, affects 'em at the *same* Time; the one, as at XII at Noon; and the other as at II in the Evening, with regard to her *present* Position: Yet, in Consideration that High-water reacheth neither Place, 'till she has pass'd the said Line fifteen Degrees to the *Westward*; that *Hour's* Space, which was added to the II at C. Finister, to make Tide at III; must be *subtracted* from the XII at *Manomy* Point, to leave XI only; according to Observation.

Now, to turn the *Compass* around upon the Central XII, according to the *same* Extent; as soon as this spreading *Secondary* Tumour, toucheth C. Finister at III; it doth the like, to the *Easterly* Promontories of *Europe*; from the utmost North of *Ireland*, to the farthest South of the *Canaries*: So on the opposite Coast of *America*, the said XI, is derived from *Manomy* Point in *New-England*, to *Pennamob* River, *Boston* Harbour, the R. *Pennamob*, &c. towards the *Northward*, as far as the *Compass* of our Observation, and the Sphere of *Navigation*, extends; while the *Primary* Flood, topples the *Revolver* of its Circle, beyond that Extent; from C. *Bajader* in *Africa*, to C. *Florida*; and thence along the *American* Shores, up to *Guy-Bad* in *New-England*, to the *Indians*: So exact was the Account of the *Tide's* Tides, amongst themselves;

but how it comes to pass, that this *Secondary Sort*, which consists of *one single Hour's Diffusion*, shou'd affect the Places aforesaid, *three Hours later* than they ; will more fully appear, in the following *Section*.

S E C T. V.

Of the mutual Occurrence of the Primary, and Secondary Tides, at the Places aforesaid.

THE *three Hours* Precedence of the *former Sort* of Tides, being already *evin'd*, by many Instances produc'd for that purpose ; and concerning their mutual Occurrences, I here only insist upon those *four Places*, which are remarkable, for the joint Continuance of both their Circuits in one, *viz.* at *C. Bajador*, and the *Canaries*, on the *African Side* ; and *Gay Head*, and *Manomy Point*, on the *American Coast*.

Concerning their *former Conjunction*, the *Guinean Pilot*, tells us in general Terms ; that a *S. Moon* makes High-water at the *said Cape*, at XII ; and a *S. W. Moon*, at the *more Westernly* of those *Islands*, at III ; that is, *three Hours later* ; leaving us to calculate the several *Instants of Time*, and *Points of Place* of their *immediate Occurrences* ; from her correspondently diverse Aspects, all the while.

Contrariwise, our *West-Indian Pilot*, to satisfy our Curiosity, even to the nicest Particulars of their said Occurrences, from *Gay Head* to *Manomy Point*, in both respects : Af-

ter an accurate *Description* of the Coast of *New-England*, he gives us a general *Tide-Table* for the whole Extent; to which he subjoins a *Map*, which specially exhibits the *Situation* of the *Gulph*, on the *South-Side* of those Territories, where the Tide arrives first at *Gay Head*: From whence the *Tide-Table* designs its *Traverse Passage*, for *three Hours* Space; that is, from *Gay Head* at VIII^h, 'till it meets with the *Secondary Tide*, at *Manomy Point*, at XI^h; to make his *three Hours* Computation of their Occurrences here, to correspond exactly with that at *C. Bajador*; and withal to express, after a more special Manner, the *Points*, and *Instants* of the Performance. Take here (according to the *Pilot's Appointment*,)

The General Tide-Table of New-England.

		Hour.
High Water at the	N. W. Point of Block-Isle, and Gay-Head. } { S. E. by East. VIII ^h .	
	Harbour of New-London. } {	
	East-End of Fisher's-Isle, and Tarpolin-Cove. } { S. East. IX.	
	The Horse-Race, and Cape-Poge. } { The Moon } { S. S. East. X ^h .	
	Manomy Point. } {	
	Plymouth; and Boston Harbour. } { S. by East. XI ^h .	
	Penequid River. } {	

To describe the *Course* of the Tide, thro' that *Coasting Gulph*; according to the *Table's* Account, and the *Map's* Direction;

First, The Flood sets from the S. Sea into that Gulph, thro' the *Streight* between Long-Isle

Isle and Martha's Vineyard; and is divided in its Passage, into a *Western* and *Eastern* Current; the former, being deflected by *Mentock-Point*, towards the *N. W.* Cape of *Block-Isle*; while the Backside thereof, deflects the other Branch of the Stream *Eastward*, towards *Gay-Head*; where, upon an *equal* Repulse, the Flood is made to swell at both Places at once, to wit, at *VIII* $\frac{1}{2}$; an Hour sooner than elsewhere, upon that Coast; but exactly when it makes at *C. Bajador*; tho' above a thousand Leagues distant from it.

Next, The *Western* Current, deflects its Course to the *S.* End of *Fisher's-Isle*, while the *Eastern* passeth to *Tarpolin Cove*; and both swell at *IX*, (which is near the *regular* Hour) in accord with the *Central* Flood of the *Atlantick*, at *XII*; which, being also of the *Primary* Sort, and rais'd by the same *Libration*, swells near the same Time; all Impediments being remov'd.

And, to pass from *Fisher's-Isle*, to the *Horse-Race*, which runs between it and *Gull Isle*, where the Water ripples for fast, both at Flood and Ebb, tho' the Channel be *twenty Fathom* deep; yet the Tide (having the Gulph to fill as far as *New-York*) floods not, 'till the *Eastern* Current have crept over the Sands, to *C. Poge*; that is, at *X* $\frac{1}{2}$; an Hour an half later, than at the *S.* End of the aforesaid *Isle*.

After all, this Stream reacheth *Manomy Point*, at *XI* $\frac{1}{4}$, where it meets with the *Secondary* Tide; which arrives there from the *Central XII*, at the same Instant; and three Hours later than it made at *Gay-Head*, viz. at *VIII* $\frac{1}{4}$; and at the same three Hours Distance,

that the *Secondary* Flood occur'd to the *Primary* XII, at C. *Bajador*, viz. at III Afternoon.

Hence plainly appears, 1st, That the *Primary* Tide, which devolves from the *Central* XII, requires only *one Hour's* Precedence, to spread the *Secondary* one over the *Atlantic*, to the utmost Extent of its Circuit : 2^{dly}, That it acquires but *one single Hour's Acceleration* extraordinary, by its Appulse to C. *Bajador*, and *Gay-Head* ; where it obtains a *second Hour's* Precedence, before the said *Secondary* one : 3^{dly}, That the *third Hour* is advanc'd only respectively, to the different *Position* of the Moon ; which, by her *Diurnal Tendency* to the *Westward*, *fifteen Degrees* beyond the *Central Meridian*, seems to *add* to the *Easterly-bound* Tide, an *Hour's* Retardation ; to make at III, instead of II Afternoon ; as it doth at C. *Bajador*, in respect of the *Canaries* : And contrariwise, from the *Westward-setting* Flood, *subtracts* the same Space of Time, by her Tendency to the same Point ; so as to make it flow at XI, at *Manomy-Point*, instead of XII ; that, as the *Southing Primary* Flood, at C. *Bajador*, preceded the *Secondary* III at the *Canaries*, at *three Hour's* Distance ; so may the *Primary* VIII $\frac{1}{2}$, at *Gay-Head*, correspond to the *Secondary* XI $\frac{1}{4}$, at *Manomy-Point*, to an Instant.

§.

So exact is the Accord of the *Primary* Tides of this Sea, as to reach their Summits *every where* at once, by *Libration* ; and their *Secondary* ones, which swell by *Undulation*, flow at

as

as equal a Time, around their Circuits : And both Sorts, observe as persicely a *three Hour's* Distance from each other, between their *Northern Tropic*, and the *Artick Circle* ; as I have demonstrated : And, to evince, that they hold as strict a Correspondence, both as to Time, and Place, with those on the *other Side* of their common *Axe*, between the said *Tropic* and the *Equator* ;

First, concerning the *Primary Sort* : Where-as the Water flows upon the *Central Meridian* of this Tract of Sea, about *twenty-three Degrees* Latitude, on this Side of the *Tropic* ; it is answer'd by VI, upon the *same Meridian*, where it Intersects the *Equator* ; not far from *Ile Cajana*, where the Tide makes at VI : And at the Mouth of the *R. Amazonas*, a Quarter of an Hour later ; which corresponds, by *Counter-Libration*, to XII at *C. Bajadar*, to VII $\frac{1}{2}$ at *Carolina*, and VIII $\frac{1}{2}$ at *Gay-Head*, &c. as aforesaid, at the *same Time* ; tho' diversly denominated by the Moon's *different Aspect* to those *three Places*, at one and the same individual Instant.

Next, as to the *Secondary Tides*, which are deflected from the *Primary XII*, on the Center of the *Atlantick*, towards the *Eastern and Western Shores* ; the III^s, described on the *Western Promontories of Europe, and Africk*, on this *North side* of the *Tropic* ; are answer'd by IX^s, on the other in the *South* ; at *C. Blanco*, and *Sierra Leone* : As the XI^s, along the *Eastern Coasts of New-England*, are, by the IV $\frac{1}{2}$ instead of V $\frac{1}{2}$, at *Surinam* (if it had lain at an equal Distance from the said *Meridian*) :

To

The Tide's Course delineated,

To answer the said XIth, at *six Hour's End* ; viz. As at the *former Place*, near an *Hour* before the *Moon's Southing* ; so at the *later*, as long before her *Setting* ; to make their *Returns six hourly*, from each *Side of the Tropick*, alternately ; whether they be of the *Primary Sort*, made by *Libration* ; or of the *Secondary*, which are deflected from 'em by *Undulation*, at *three Hour's Distance* ; and happen so much later.

Such is the *general Accord* of these *Tides*, in all *Places*, and so mutual is their *Correspondence* of *either sort*, amongst themselves, on each *Side of their common Axe* : And their *Motions* are still so proper, and fitly adapted to the *Places assign'd* ; and their *Performances* so distinct, and pursuant to each other, that they must necessarily depend upon some *Universal Cause* : And still keeping as exact *Touch* with the *Course of the Moon*, in all *Cases* ; and most resenting her *Presence*, by stooping *lowest* to it ; and the *Water mounting highest* in her *Absence*, by *Rebound* alternately ; her *Pressure* must *first cause* them, and their own *weight Advance*, and *propagate* 'em afterwards by *Libration*, and *Undulation* (as *aforesaid*) in the wide *Ocean* : But, lest the great *Diversity* of their *Performance*, in this most *irregular* and *unaccountable Sea*, thou'd seem particularly to *obscure* this great *Truth*, and raise *Doubts* to the contrary ; I shall endeavour to clear 'em all off, one by one, in the following *Section*.

HTHO







S E C T. VI.

seeming Irregularities of the Atlantick Floods, amin'd, and clear'd.

IRST, Whereas it may be *objected*, that the *Atlantick Ocean*, being of no regular *Figure*, cannot admit of a *Center* in the best Sense, more than any *Conick Section*, or *Circle* excepted : *Ans.* What I assign, is such a *Point*, or *Place*, as seems to be regarded by the *Tide's Diffusion*; as spread itself from thence with most *Equality*, towards the surrounding *Shores*.

Secondly, That no *one Place* seems assignable, since the *Tide* can possibly so affect the *Shores*, as to make at once, on the *Western* Frontiers of *Ireland, France, Spain*, and *Portugal*, whose utmost *Points* lie almost in a *straight Line*, for near *five hundred Leagues* together : *Ans.* Yet, that *Part* of the *Atlantick*, which is affected, being partly *Triangular*; the *Tropick*, which is the *Axe* of the *Tide* affects it, being its *Base*; a *Tumour* of the same *Figure*, and such as the *American* *Shores*, on the one *Side*; and the *European, African* on the other, will admit; and which is form'd, as in a *Mould*, by their *Revolutions*; is sufficiently accommodated to complete the *Work*, at near the *same Instant*, on the *Shores* abovesaid.

Thirdly, To urge this *Difficulty* farther; it is not practicable for the said *Tumour*, to reach the *Bottom* of the *Bay of Biscay*, even to the *Mouth* of the *Garrone*, as soon (within half

quently the *deepest*, to make way for it, other on the Coasts of *Europe*, or elsew (that one, near the *C. of Good Hope*, except And, on the contrary, were not the Promontories fronted afar off, and guard shallower Water, and *shelvy Bottoms*, from hasty Approaches, and Insults of those Tumours, they must necessarily be *sooner*, than they be at present.

Asbly, Yet be the Conveyance of Water, as *speedy* as it will, the *Centre* of the *Atlantick*, cannot be diffused *Streight of Gibraltar*, by Anticipation ; as the Moon *Souths* upon it ; which an *Hour* and a *half* before the Sea be full on the Great Meridian : *Ans^w*. To this *reply'd* ; that the Moon brings along with her thither *another* Flood, by her immediate influence upon the *Mediterranean* Sea ; which its Occourse with the *Central* Half-Tide *Atlantick*, jointly swelleth the *Streight*

the *Midland Flood*, to hasten it ; nor can it proceed so speedily from the *Central Tide* of the *Atlantick*, at so great a Distance from it : *Ans.* Nor is it requisite to flow from either of em ; or partake with 'em ; more, than to be also supply'd, immediately with Water, from within the *Tropicks* ; and by the same Tidal Undulation, which replenisheth the rest of the *Atlantick*, and at the same Time ; having its proper Channel, between the *Canary Islands* and the *African Shore*, to convey its proportionate Part of the Stream all along, from the *Equator*, thither ; as soon, as to any other Part of the Sea ; and by Inclination of the *Shores* on both Sides, to raise the Tide there *an Hour* sooner, than at the Center of the *Atlantick* itself.

6thly, If it be still insisted on ; that, to the contrary, about *Cape Cantin*, near the Middle of the said Shore, between the said *Streight* and *Cape Bajador*, (upon both which XII is affix'd) it flows not 'till I ;: *Ans.* It is not to be wonder'd at, that the Flood shou'd come so much later, to the Middle of that Coasting Current, than to both the *Ends* thereof, upon whose Floods it jointly depends ; as being the proper Cause, whereby it is produced ; and consequently it must swell later, and not withdraw itself again, 'till after their Departure.

7thly, If the Tide seems to be either too quick, to make at *Cape Bajador* at XII ; or too slow, not to reach *I. Canary* 'till III, afterwards : *Ans.* At the former Place, it is furnish'd with Water immediately from the *Equator* ; and is withall, accelerated by inclining *Shores* : Whereas, at the later, it expects the Defluxion of a *Secondary Flood*, three Hours longer

longer, from the Center of the *Atlantick*, to which it lies exposed.

8thly, If it be objected ; that, at *C. Blanco*, it makes *six Hours* later, than at the said *Isla* ; to wit, at *VI* ; tho' both lie in the *same Degree* of Longitude ; and in Latitude not above *ten Degrees* distant from each other : *Ans^w* : It is, because they lie on *different Sides* of their *Axe* ; and so are *counterpos'd* to each other, at *six Hours* Distance, tho' they lie so near together.

9thly, Yet it does not appear, why *Sierra Leone* has two *distinct* Tides, the one at *VII*, and the other at *IX* : *Ans^w*. It is, because they are derived regularly, from two as *different* situated Oceans : The former from the *Ethiopick*, and the later from the *Atlantick* ; and they correspond each to their respective Tides ; the *VII*, being consequent to that of *R. Serbera*, which swells an Hour before it ; and the *IX* to the *III*^s, on the *Western Promontories of Europe*, &c.

10thly, At *R. Gojaven*, 'tis Tide *two Hours* sooner, than at any other Sea-port, on all the same Coast : *Ans^w*. 'Tis, in regard *Cape Palmas* over-shooting the rest, *drives* the Current of the Sea into the Mouth of the River, with so much Precipitation, as to *hasten* and raise the Tide, at their joint *Appulse* to the Shore, to a *greater Height*, than to be kept up any longer to the same Pitch.

11thly, The Water floods twice, at *I. Cajana*, at two Hours Distance : *Ans^w*. That is to say, *once*, being *over-hastily* swell'd, like that at *Gojaven*, by the joint *Appulse* of the Flood, and Current, to the Shore so much too soon ; and the *second* Time, not before the regular Hour.

Last

Lastly, The Flood at *R. Gabon* at VI, anticipates those on our *Western Promontories*, which swell not 'till the third Hour, after the Moon's Southing upon 'em; and shou'd happen at IX, to correspond with the III^e at the C. of *Good Hope*, beyond the *South Tropick*, at six Hours Distance: *Ans^w*. The Parity holds not, on a double Account; this Flood at VI, being *Primary*; the Stream which supplies it, cleaves to the *North* and *South* Shore, which juts out into the Ocean to meet it: Not a *Secondary* one; to expect the Moon's passing forwards two Hours, and the Flood's Return back to the Shore in the third Hour, before it can possibly happen.

After all, if it be *question'd*, why *R. Gojaven*, *Caran*, *Rey*, and *Monamba's Hole*, each swell twice in one Hour's Space, above the rest of those Rivers on the same Coast. *Ans^w*. 'Tis because the *Mouths* of the said Rivers, are remarkably *reflected* towards the flowing Water; which, being obliquely driven by a *strong Sea-Current*, swells highest at its Appulse to the oppositely reflected Shore, two Thirds of an Hour, before its Flux ceaseth: And sinking a while, after the Briskness of the Flux is over, remounts again with the flowing Water, to its utmost Pitch; the Top of the Tumour being, as it were, divided into *two Half-tides*, before it pass into an Ebb.

But, to cast an Eye of Reflection upon the *Western Shores*; the Appearance of *Irregularity* seems, at the first Sight, to exceed all our pass'd Observation; viz. That an *E. S. E.* Moon shou'd make at *Florida*, at VII¹/₂; along the *Virginean Coast*, a *S. E.* at IX; and a *S. E.* by *E.* at VIII¹/₄ at *New-England*: But, upon a second

second Inspection, subtract *one Hour's Acceleration* from *C. Florida* (*Virginia* being regular) and another from the Account of *New-England*; and at the *First* Place, it makes at *VIII*¹/₂; at the *Second*, at *IX*; and at the *Third*, at *IX*¹/₂: Which agrees exactly with the Moon's different Positions to the *Declivity* of those Shores: So as to adjust the Tides, at all those *Three Places*, to the *same* Time.

CONCLUSION.

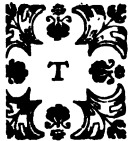
Having examin'd the various Appearances of the Tide, in our *Western Ocean*; and clear'd the seeming Irregularities of the *Atlantick* Part, in a special Manner; which, for Multitude and Diversity, must exceed all that are incident to the other Divisions of that Wilderness of Water which encompasseth the *Universe*; as much as the *Anomaly* of its Figure, and the *Unaccountableness* of its Situation surpasseth theirs: And this, with regard to the sole Efficiency of the Sun, and Moon, by Means of their common Instrument, *Pressure*; proceeding constantly from the Cause to the Effect:

Now, upon my Departure from the wide Ocean, to our narrow *British Seas*, I am, & *Converso*, to argue from the Effect to the Cause; that is, from the inextricable Maze of *Channels*, and *Currents*, and the confused Scene of Tidal Occurrences, which it exhibits, not to be parallel'd: That, upon a clear and manifest Display, they are all reconcil'd amongst themselves, with that Perspicuity, as to exclude all reasonable Doubt to the contrary; and that they are all conformable to the same Order of Nature, and Laws of Motion.



C H A P. IV.

Of the Tide's Reception into our Irish and British Seas.

 O give the Motion of the *Tide* a successive Designation, in both the propos'd respects ; First, as to the *Place* whence it is to be drawn, it is the Center of the *Atlantick Ocean* ; where it is rais'd by *Libration*, and wells alike by *Result*, from the New and Full-Moon's Pressure ; but is not full Sea there, till they have attain'd to their Meridional height between the *Tropicks* ; and so cannot reach *Ireland* by *Undulation*, till after their coming : Hence the Primary Full-Moon, Secondary New-Moon Tide, which makes *Midnight*, and usually visits the *West* of *Ireland*, at III, and the *West* of *England*, at IV the Morning ; and is call'd the *Day-Tide* ; its most opportunely to be made Use of, as remaining under our constant Inspection, from Morning till Night.

This Secondary New, or Primary Full-Moon Tide, no sooner visits the *West* of *Ireland*, but divides itself by *Fluctuation*, or a saved Flux of Stream, into N. and S. Floods ; and each Stream sub-divides into Two more : the two innermost, including the Principality of *Ireland* only, re-unite themselves at the *Head of Man* ; while the other Two outwards

R

bound

some other respect: So that every
thereof is to be traced along its res-
Stream, apart; and first down the Mi-
the Channel, where it is least Obnox-
such Impediments.

S E C T. I.

*The Tide's Division, by sundry Channels;
gressive Motion, thro' as different Roads
Regard to the TIME and PLACE of
Water.*

TO begin with the *English Channel*,
lies nearest to our Inspection, and
deserves it, both for the Multiplicity and
variety of its Appearances; and trace its Course
from the Promontories of *Ireland* (which it
makes, on the *Western Coasts*, at III; and on the
Southern, at IV in the Morning), at

Dartmouth, at VII; Portland, and Weymouth, at VIII; by the *Isle of Wight*, at IX; till it reach Dover, at X and $\frac{1}{2}$: And having pass'd the *Streight*, and left *Calais* after XI, it comes to *Dunkirk*, on the *Netherland-side*, about XII; passeth by *Gorée*, at I and $\frac{1}{2}$; and before the *Maes*, at II $\frac{1}{4}$; and reacheth the Clifts of the *Texel*, at III and $\frac{1}{4}$; still following the Direction of the same Shore, all along the *North Sea*, or *German Ocean*.

But deflecting thence towards the *South Sea*, which lieth before *Amsterdam*, thro' the *Streights* of *Texel*, at VI; and of the *Fly*, at VII; and following their several Channels, along the Coast of *Friezland*, till VIII; they conjoyn into one, at IX; which passeth by *Horn*, at XII; comes to *Amsterdam*, at III; and arrives after all at *Harlem*, where it finisheth its Course, at IX: So regularly Progressive is the Tidal-Flood down the Middle of our *English Channel*, and along the Coasts of *Flanders* and *Holland*; and so punctually are its Stations set down, on each Side; where Ports, as it were *Land-marks*, point out what Way its Tumour makes, even to an *Hourly Performance*; on Our Side, from the *West* of *Ireland*, as far as *Dover*; and on theirs, from *Calais* to *Amsterdam*.

And, to return to the Western Coasts of *Ireland*, whence the *Northward-bound Division* of the aforesaid New and Full-Moon Flood departed, at the same III Hours; it arrived to the West Side of the *Orcades*, at IX in the Morning: But being to encompass also the *Shetland Islands*, at two Degrees farther North; and withal to swell the whole Extent of Sea, between the Coasts of *Norway* and

The Motion of the Tide,

those *Islands*, before the Flood cou'd be reflected thence, and reach the same Height on the East Side of the *Orcades*, it arriv'd not Thither 'till III in the Afternoon : Nor did it affect the Road before the *Fair Isle* (which lies betwixt 'em) 'till about XI ; (which is their *Mean Time*,) as is found by Experience.

But to continue the said Flux of the Tide from *Fair Isle Road*, where it swells after XI, down the *German Sea* to the *Dogger*, where it meets with the *South Flood*, and incorporates with it ; It is to be observ'd, that it exceeds not XI and $\frac{1}{2}$, along the Coast of *Norway*, 'till it have pass'd the *Naze* ; and so continues to make at XII, or thereabouts, along *Denmark*, and the *Futland Islands*, 'till it reach the *Elbe*, at the East-end of the said Bank : And as the Tide makes not, on the *Shore of Fair Isle*, 'till about III in the Afternoon ; that is, *four Hours later* than it does in the *Road* : So upon the Coasts of *Scotland* and *England*, it continues to make so much *later*, than on the opposite Shores of *Norway* and *Denmark* ; that is, either at, or after III, on the *Forelands* of both Nations ; 'till it reach *Flamborough-Head* about IV, over against the Road aforesaid.

Now it is remarkable, that, altho' the Flood passeth along *Norway* and *Denmark* by a straighter Coast ; and withal according to its first Direction, from within *Fair Isle Road* : And, on the contrary, is considerably deflected from it, towards the *Scotch* and *English* Shores ; yet its Course to *Doggerbank* is dispatcht, on both Sides, at the same Rate ; to wit, on the Former, between XI and XII ;

and

and on the Later, between III and IV ; that is, within the Space of *One Hour*, on either Side alike : Hence it must be concluded, to do the same down the *Middle Stream* (where it meets with no Impediment) ; and to make upon the *Middle* of the said *Bank*, at XII ; and perhaps somewhat sooner at the *East End* of it, and later at the *West End* ; or rather, in regard that the *South Tide* meets it briskly towards the *West*, and decays afterwards ; 'tis *Full*, all along from the one End to the other, at the same Time.

Having thus disclos'd the *Place* of the Congress, of the N. and S. Floods, to be the said *Sands* ; and the Time to be at XII, by the Length of their Courses thither, in both respects : It is farther manifest, that they joyntly rais'd the said *Bank* as a Barrier, to break their mutual Insults upon each other ; and that the *Elbe, Rhine, Maes, &c.* brought down their Wreck from *Germany, Switzerland, France, &c.* which composeth it ; being not a Work of the *Creation*, but a Heap of *Mudd*, wash'd, by the beating of their Waves, into a *sandy Bank* ; planed on all Sides, into a rectilinear oblong Figure, by the *Streams* which laid it there, to cover the Coast whence it came ; and that it became separated from the Land, by the Interposition of the *South Flood*, which struck in betwixt it and the *Netherlands* ; and finally, was parted at each End, from the *English* and *German* Shores, by Channels made by the *North Tide* ; which slop'd off its nether Corners, to leave a free Communication betwixt their Streams : As the greatest *Rivers*, when they cast up Banks of Sand, to secure

their Ports, commonly keep *more* Channels open than one, to disembogue their Floods with more Freedom into the Ocean.

So constant and regular is the progressive Flux of the Tide, down the *Middle Stream* of its Channel, around our Coasts: Let us see what *Rubs* it meets withal near the *Shores*, to hinder its Passage, or deflect its Course into so great a Diversity of Motion, as to be otherwise unaccountable.

S E C T. II.

Observations and Reflections upon the Division, and Progression of the Tide, described in the precedent Section, with regard to the Shores.

TO begin my Reflections on the *West* of Ireland, where I first enter'd upon the said Description; it is observable, that the Tidal Flood found a *free and open* Passage before the *South Coast* of that Kingdom, 'till it enter'd the Chops of our *English Channel*, between *Ushant* and *Silly*; and held on its Course to the *Eastward*, down its *Middle Stream*, at almost the same Rate, of Time and Place progressively, from the *Lizard* to *Dover*; the Coast being favourable, and its *Forelands* lying almost in a direct Line; and the *Bays* betwixt 'em being so little depress'd, as to give it no considerable Stop, or Deflection, for at least a *hundred Leagues* together.

Whereas, on the contrary, it is no less remarkable, that athwart the *South* of England,

beyond the Channel, on the *French* Side; that Tract of Sea, which corresponds to ours, is divided into *Two Bays*, or *Gulphs*, of a large Extent; the One, reaching from *Ushant*, to *Cape Hague*; and the Other from *Cape Bar-Teur*, to *Calais*; which break the Course of the Flood, on that Side, as it were into *Starts*, from one Head of Land to another: And certain several *Rocks*, and *Islands*, which often stop, and sometimes force the Flood to recoil whence it came; after they have rais'd its Tumour to its full Height, two or three Hours sooner than ordinary.

The first *Rub*, that this Eastward Progression of the Tide meets with, is the *Western Shore* of *Ushant*; upon which, its Flux from the Ocean, falling, as it were, from a higher Sea into lower Water, raiseth, by Rebound, a greater Tumour, than to be supported by the Flood which brought it, any longer than the Dint of its first Impulse lasteth; and by this means, makes at III and $\frac{1}{4}$ in the Morning, *two Hours* sooner than in the *Channel* it self; which has the *Gulph* below it to fill, before it can arrive to its full Pitch, at VI: And the like happens at *Garnsey*, some Leagues down the Current; where, to the Sea-ward, it makes at V and $\frac{1}{4}$; yet, in passing down the Channel, not 'till IX and $\frac{1}{2}$, full *three Hours* later: And it must do the like, at all other Places, which *confront* the Flood, to set it on; and are *flank'd* by Channels, to carry it off again.

After the Tide has pass'd the *Ushant*, the next *Rub* that falls in its Way is the *Normand Promontory*; which dams the Stream on that

The Motion of the Tide,

Side, transversly, from *Cape Hague* to *St. Malo's*, which lies in the Bottom of the Bay; where 'tis Flood at V and $\frac{1}{2}$, and the Highest perhaps in *Europe*: so that it both precedes and exceeds That in the Channel at *Ushant*, whence it Flows; tho' at *twenty Leagues* distance from it; which seems ('till both be well consider'd) to make the Effect to anticipate, and surpass the Cause that produc'd it: And the like must happen, proportionably, upon all that *Coast*, from the *Cape* to the *Port* aforesaid; and consequently co-extend to the *Gulph*, along the *French Shore*, from *Ushant* thither.

But the Flood having pass'd thorow the Streight, between the said *Cape* and the *Start*, down its common Road; while it slips by *Portland* at VIII, the *Isle of Wight* at IX, and reacheth *Dover* at X and $\frac{1}{2}$, it spends all that Time in doubling the *Cape Barfleur*, before it arrives at the Road of *Caen*, where it makes at X and $\frac{1}{2}$: And continues to do the like at the same Hour, all along the *Coast* of *Normandy* and *Picardy*, from before *Caen* down to *Calais*: The Lines of the Tide's Diffusion from its direct Course, to those Transverse inclining Coasts, growing still proportionably shorter, and consequently supplying 'em with Water so much quicker; 'till their Distance, both in Time and Place, be concentr'd in a Point, at the Streight between *Dover* and *Calais*; so as to render the Making of the Tide, along those Coasts, with regard to its Eastern Course, instantaneous.

And from the Streight at *Dover*, the Sea is full before the *Downs* and *Harwich*, as far as *Tarmouth Road*, at the same Hour that it Floods

on

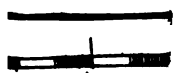
on the Coast of *Normandy* and *Picardy*, for above sixty Leagues together; tho' it be diversly occasion'd: Because, along those Provinces of *France*, the Shore so inclin'd towards the Middle Stream (which swell'd successively) that the farther they went, it was proportionably the quicker supply'd: But here, upon the Coasts of *Essex*, *Sussex*, &c. the Flux of the Tides, being partly resisted by the Sands before *Yarmouth*; and partly repuls'd by the Occurrence of the Northern Flood, swells equally at both Ends, and thro' all the intermediate Tract of Sea, at once; as also upon the same direct Line, as long as the Water riseth at *Dover* to supply it; that is, for five or six Hours Space; to make High-water all along, from *Caen* in *Normandy* to *Yarmouth* in *Norfolk*, at the same Instant.

And when the North and South Tides meet afterwards upon the said Sands, at XII, and become united into One; it is after such Manner, that altho' their joint Flood co-extends to the whole Coast of *Flanders* and *Holland*, at the same Hour, on the Road, so as to fill All full, at once; yet it creeps progressively upon the Shores, for five Hours together; that is, from *Calais* about X in the Morning, to *Texel* near III in the Afternoon; as I have already described; each Flood, notwithstanding their Conjunction, persisting to produce its special Effect: For, in regard the *German Sea*, opens a Mouth wide enough towards the Northern Ocean, to receive its Tidal Impression in full Measure; and is deep enough, to convey it entirely to the *Dogger-bank*; and continues to the same Breadth, to comprehend it all at once;

once; 'tis proportionate, in every respect, to effect it *All* at the same Time, especially being *directly* objected against it: And it is no less proper for the *South Flood*, inasmuch as it is sharpen'd by the Streightness of its Passage, at *Dover*; and withal, directed towards the *Netherlands*: To continue its Flux at a competent Rate, along their *Shores*, in compliance with the Impulse and Direction aforesaid.

After all, this Coasting Tide sets, from the *N. West*, upon the Clifts of the *Texel*, at III Afternoon; and at IV, at the *Fly*; yet makes not *before* them 'till VI and VII at Night; being deflected from its *Easterly* Course, into the *South Sea*: And withal, being almost spent by passing over the Sands, makes so little Way down their crooked and narrow Channels, on the Coast of *Friesland*, and before *Horn*; that a second Flood succeeds this at *Texel* before it can reach *Amsterdam*; and *six Hours* e'er it advanceth to *Harlem*, to finish its Course; as 'tis delineated in the following Map of *Holland*.

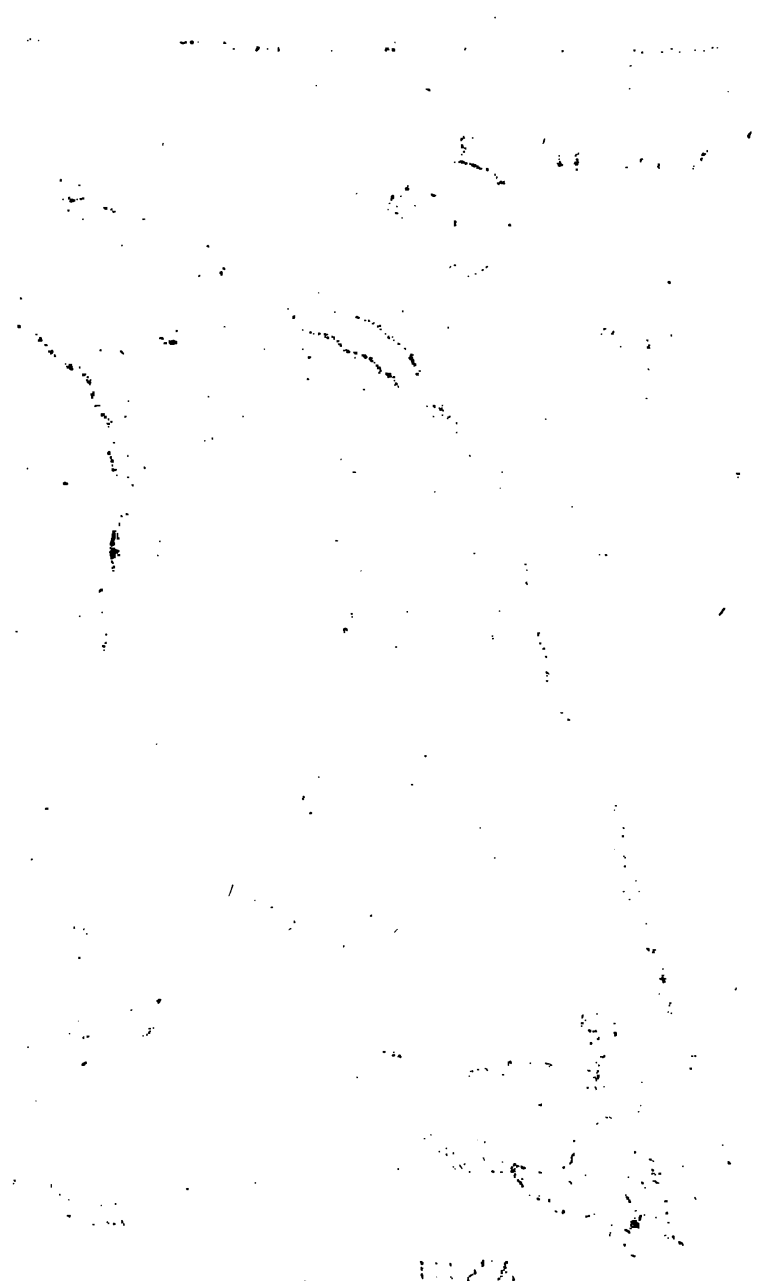
Such is the Speed and Regularity of the Flood, in *direct* and *open Channels*, as I described in the last *Section*; and, on the contrary, it becomes so disorder'd, and retarded by *deflecting Shores* of *shallow Water*, as I demonstrate in this; the Tide flowing all the while: But *Why*, upon its Ebb, it shou'd make High-Water in some Places, where it was Low before, still remains to be discuss'd.



NORTE

SEA





S E C T. III.

the Flux of One Tide produceth Another by its Reflux ; and that One Flood may become Many, by a diverse Application to the same Shore.

THUS far I have traced the *Course of the Tide*, as proceeding from the Ocean progressively, either by a *direct*, or *deflected* path ; and display'd its sundry *Appearances*, on both accounts : But being found by Observation, that its *Reflux* sometimes raiseth *Turbours*, where the *Flux* had produced none before ; and all this while, no greater quantity of Water was return'd by the same Channel on occasion it ; especially it happening near the time of *Low-water*, and after so odd a manner ; that whereas in some places, the *rising Flood* only wash'd the *Shores*, the *re-falling Ebb* spared them, and swell'd the Channel ; and in others, the *Flood* made *High-water* to the *Sea-ward-side* of the *Islands*, and the *Ebbing-water* to the *Lee-ward* afterwards : Yet, 'tis Remarkable, that, in those Cases, the *Inclining Shores* render'd the *Tide*, at its return, so much more compact and forcible, by contracting its Stream closer together, as to perform the said Effects.

For an Instance of the former Sort, it is observ'd to be *High-water* at *Dover* about X and $\frac{1}{2}$; and at *Calais* at XI in the Morning ; yet in the *Streight*, or *Channel* between them, not to swell to the same Height, until III in the afternoon, upon its Stream's return from the

the Coast of *Flanders*: For, whereas the Current, passing thro' the Streight afore said, between X and XI, had free liberty, upon their Confinement, to mount *both Shores* at once; yet cou'd not rise to its full Height in the *Channel*, being carried off too speedily, three several Ways at once; viz. towards the *Downs*, *Flanders*, and *France*: But now at III, upon a triple Confluence of all their Streams, in the Mouth of the said Streight, it becomes swell'd up in the Middle, by 'em *All* at once; and yet its Tumour is so buoy'd up from each Side, by the Occurrence of the two adverse Streams, from the *English* and *French* Side, as not to let it affect the Adjacent Shores.

Of the *later* Sort is the Tide at *Ushant*; where it makes, by its Flux from the Main, into the Bay towards the *West* at IV and ' in the Morning; and yet is not full Sea, on its *East* Side, by its Reflux out of the Channel, till XII at Noon; the Stream, on its return along the *Inclining Shore* of *Little-Britain*, being more contracted, and hasten'd Thither-ward; than towards the opposite Side of the Island, where it flow'd before.

The like happens at *Garnsey*, which lyes situated in the Sea, upon *Cape Hague*, the Foreland of all *Normandy*; which, straightning the *South Channel* to the *Half*; maketh the Ebb, at its return from the *East*, to fill that Side of the Island full at XII and '; that was empty before; when it Flow'd at VII, on the contrary Part: And the same Judgment is to be made of all other *Islands*, which lye Open to receive the Flux of the Tide, on the one Side; and withal near some *inclining*

clining Shore, to contract its Reflux more Intensely, on the Other.

And upon all the abovesaid Accounts, the Flood affects the *Isle of Wight*, on all Sides relatively, at different Hours: First, on the *West Side*, as being directly oppos'd to the *winning* Stream, the growth of its Tumour is frequently hasten'd by it, so soon as to in the Morning: Next, on the *South* which lyes towards the Channel, the is carried off again by it, at IX: Then, on the *N. West*, where the Tide and the Race meet on the backside of the *Isle*, before *Calshot*, the Water is full at XI: After that on the *N. East*, the Flood has at *Portsmouth* a Harbour to fill, which detains it till past XII: And finally, it expects the Reflux of the Stream out of that Port, to meet the Ebbing Water from *Winchelsea* and *Dover*, at full East; to swell on their Occourse there, higher than before, about I and $\frac{1}{2}$; having spent full five Hours space, in surrounding so small a Spot of Ground; which is near half as much time, as sufficeth to do the like to all *England* and *Scotland*, conjoin'd.

The like diversity of Tides, is also found to affect *Capes*, *Promontories*, &c. upon their different Applications; as the *Start*, *Flamborough-Head*, the *Lizard*, &c. that are washt by *thwarting* Streams, which hasten their Tides on that Side, towards the Ocean; till they be let off again down the Channel, and are deflected afterwards to the *Leeward* successively, both to prolong their Continuance, and repeat their Tumours, by a diverse Access to the same Place: As without *Calais*, to be full

full Sea at I and $\frac{1}{2}$; towards Dover, at III; $\frac{1}{2}$ in the Creek, at IV and $\frac{1}{2}$; without the Road, at $\frac{1}{2}$; and at the Peer, at XII: Nay, sometimes it is *Progressive* on one Side of a Cape, and *Retrograde* on the other; as when it is at X before Dover, it advanceth two forward towards *Quinborough*; and seemeth to retire as many backward to *South-Ham* to make full Sea at XII, with the *Southern Moon* at both Places.

But in case those *Promontories* &c. directly into the Main, as on the *West* of Ireland, where no such Currents thwart the Tide affects 'em an hour sooner, than the *Bays* within the *Capes*; and *These*, an hour before the *Ports*; whereas it fills the *Rivers* successively slower, the farther they strike up into the Land; as it doth all along the *South Coast* thereof; from *C. Clear* to *Waterford*: Hence it is High-water in the Road at *Harwich*, an Hour before the Port be full; and two Hours sooner before *Tinmouth*, than it makes at *Newcastle*; and three Hours at *Margate*, 'ere it be full Sea at *London Bridge*: And, whereas it flows on the *Downs*, at XII; at *Gravesend*, at I and $\frac{1}{2}$; and not at *London* till III; the First Stage being *twenty Leagues*, and the Last but ten; and consequently the Course of its Flux grows doubly slower; Hence we may Conclude, that it does so successively to the End of its Journey.

Finally, as to the Approach of the Tide to other *Coasts*, which are *Bold*, and hold to the same direction; 'tis both speedy, and all along Consequent to it self, to a Moment; but, if the Shore prove either *rough*, or *shallow*; or broken

by *Rocks* and *Shelves*, its Access be-
proportionably retarded; yet grows
considerably slower, unless upon some
able *declivity* from the Channel, which
it; which is visible to the Eye, and
e to the *Map* of the Place, without any
lucidation: So that having display'd
se of the Tide, as rais'd by the Moon's
; between the *Tropicks*; and diffused
e *Atlantick Ocean*, by the counterpoise
own Weight, in the Two precedent
and in *This*, having pickt up the chief
objected against its Progress thro' our
seas, and remov'd 'em out of its way,
esignation of Place, and computation
: It occurs to shew, how it becomes
'd in Height, as well as Speed, both in
row Seas which it affects; and in the
self, which produceth it.

S E C T. IV.

*Rehearsal of the most remarkable Occur-
of our British Tides, already discours'd*

the manifold Divisions of the Tide
our *Narrow Seas*, and the great diversity
hannels, have so deflected its Streams
ray at once; that no known tract of
of the same Extent, ever branch'd it
o such variety of Occurrences; that
s to abridge all those, that are any
found in the *Ocean*, within so small a
compass:

compass: I shall only recount a few, out of so great a Number; which are most *Remarkable*, and explanatory of those, which I have contingently taken notice of, but not fully Explicated, elsewhere; referring the rest to the Inspection of the *Map* thereof, whereby is drawn a Scheme, which represents 'em *All* at one view; and exhibits to the *Eye* their Connection and consequence more effectually, than *Words* can express.

First, One and the same Tide may affect several Ports at once, tho' they lye all on the same Side of the Channel, that successively supply's 'em; as along the Coasts of *Normandy* and *Picardy*, from *Caen* to *Calais*; or the Ports be situated on the Opposite Coasts; as on the *Downs*, *Harwich*, and *Yarmouth*; upon all which, it Flows all along at the same Time, tho' the Stream which supply's 'em, passeth by 'em successively, one after another, but not at the same distance.

Secondly, the same Tide may, contemporally, fill far remote Ports, by distinct Channels, if they either lye at the like distance from the Places, where their Streams were separated; as the *Isle of Wight*, does from *Dublin*; and *Rye*, from *Liverpool*; which are alike distant from the *Lizard*, where their Floods were separated: Or, the same Flood may be convey'd by two opposite Channels, reflex'd to the same Place, so as to make sometimes but one single Tide, when they meet there; or else two distinct ones, when they are driven by the Wind successively thither; as at the *Isle of Man*; when the same Flood passeth, from the Ocean, by the North and South of
Ireland,

d, diversly thither; while the same Tide
th, in like manner, by the N. of *Scot-*
and S. of *England*, to *Hull*; and makes
ne Flood there, at the remotest Distance
the Ocean.

oreover, in regard the Course of the
m, while it flows in a *direct Line*, is per-
d with most Ease, and *greatest Celerity*; and
Deflection becomes a retarding *Impedi-*
: Hence, it is High-water an Hour sooner
istol, than at *Bridgwater*, tho' it be much
r distant from the Ocean, because it lies
directer Line from it: And the Flood
s two Hours sooner at *Dover*, than at
mouth, which it passeth by, because it *de-*
out of its Road; and when it is arriv'd
er, it finds a *large Creek* to be fill'd with
r, which doubles the Impediment.

sides, the Flux and Reflux of the same
, being jointly perform'd in *twelve Hours*
e, in all Places, how circumstanc'd so-
according to the Stamp first set upon it
e Moon's Pressure, between the *Tropicks*;
ot so, as to be perform'd in *six Hours* apiece;
by how much the longer the Flux is, the
ix must be so much *shorter*, and on the
verse; according to the Capacity of the
vels which convey'em, and the Situation of
orts which receive'em: Hence, *Rivers*, tho'
y'd by the same Flood, and close together,
and Flow at *different Rates*, and seldom at
same Time; as *Mursey*, and *Ribble*: The
spends more Time in Flooding than Eb-
, and the Former does the contrary; as
ing that *Fall* of Stream, which the other
r has, to discharge itself, as soon as the
is over.

S

And

And if the Places, affected by the Tide lie in the *same* Tract, so as to be affected *it successively*, one after another; the difference of their Tides, is to be calculated from the distance of *Time*, not of *Place*: Hence if High-water at *Calais*, when it is Low-water at *London-Bridge*, and on the *Converse*; because it constantly spends about *six Hours* passing between 'em; and not because they lie at such a distance of *Place* from each other since it alike affects *Amsterdam*, and *Harlem*, tho' these be not *ten Miles* distant, and those are near *thirty Leagues*: And in case their Distance either exceeds, or reacheth *twelve Hours*, as the Tides do at *Plimouth* and *Hull*, or at *Texel* and *Amsterdam*; they cannot be flooded both at once, by the same Tidal Undulation.

Nor is it so strange, that our *English Channel*, the *River Humber*, and *Zuider Zee*, shou'd *once* make High-water, by *three different* Tides at so great a distance of *Place*; as that the *Garrone* in *Gascony*, shou'd contain *two* distinct Tides, and the said *Zee* as many at once for *six hours* space in *twenty four*; every Tide spending *eighteen hours* in passing that *River* (as well as thro' that *Lake*) *twelve hours* distance, the one from the other making High-water in the *Mouth of the River* and at *Bordeaux* at the same Instant, *different* Tides, the one succeeding the other at the said distance; and the leading Flood spending *six hours* more, before its Course finisheth at *St. Macar's*; yet fail not to make their respective Returns in due time.

Thus the Motion of the Tide, which was first impress'd upon that vast Wilderness of water, the Ocean in general; tho' throughout Homogeneous, both for time and place; rising and falling perpendicularly, upon the Equator, and alternately, in *six hours* apiece; when it was bounded with *Coasts* and *Shores*, the Tides became diversly deflected, by their *different Situations*, from their former *Regularity* in both respects; as appears by the more special Account, given of 'em within the *Atlantick*: And upon its exception into our *Narrow-Seas*, new differences in those respects arose at every turn, into such a diversity of Motions, and manifold occurrences, as I have already describ'd.

Now, in regard it sprung at first, from a few *Feet* and *Inches*, near the *Equator*; to almost as many *Fathoms* in other *Places*; I am shew, in the sequele of the ensuing *Section*, that Advantage it makes of every step it takes, from the one Extreme to the other.

S E C T. V.

Of the Tide's diversity in HEIGHT; and how it is gradually encreased, both in the Atlantick Ocean which propagates it, and in our Narrow Seas, which receive it.

TO take the Dimensions of the Tide, aright; and draw the Encrease of its *Height* and *Speed*, from proportionate Depths of *Sea*, and inclinations of *Coasts* and *Shores*, along its Course from the *Equator*, whence it has its Origin, to

our Ports, where it terminates: I here re-assume that *New-Moon Tide*, which I describ'd in the last Section, for a Pattern to follow, thro' the *Atlantick Ocean* into our *Narrow-Seas*; and remark what advance it makes at every step, in either respect.

The First Step, which the *New-Moon-Tide* monthly advanceth above the Ocean's natural Level, at the *Equator* (as we are told, from the Relation of a curious Observer) exceeds not six Foot; whereto the *Equinoctial Flood*, super-adds not above six Inches: whereas at Bristol here in England, and at St. Malo's in France, it reacheth sixty and seventy Foot, as is found by Experience: So that the Effect seems to exceed the Cause, from whence it springs, in a Decuple proportion: Now, to trace the said Steps in order, from the first to the last; and shew, from the Connexion and Consequence of the whole Series, that they arrive only to an *Equivallence* each to other, all Circumstances being duly consider'd;

First, It is observ'd, that the said six Foot of Water, which, near the Line, is spread over all that Space of the Ocean, which extends from Guinea to the *West-Indian Islands*, is contracted by *Libration*, into half that Breadth at the *Atlantick Tumour*; and consequently must be rais'd double that Height, to recompence in one respect, what it looseth in another; especially being depress'd perpendicularly by the Moon, and in a more ample Measure nearer the *Equator*, than elsewhere; After that the Lines of her Pressure are more obliquely and thinner scatter'd; to make six Foot

of Water there, more than equivalent to *twice Six*, at the Middle of the *Atlantick*.

Again, the said Tumour, diffusing it self towards the *Coast of Europe*; That Part of it, which falls on the *Westerly Shore of Spain*, and *France*, on the one Side; and on the *Southerly Coast of Ireland* on the other; becomes still more contracted, to add *six Foot* more; and entering upon the *Soundings*, their shallow Bottoms still advance it gradually, as they ascend; to superadd *six Foot* at least, before it enters the Chops of our *English*, and *Irish Channels*; being contracted as well in Depth, as Breadth, so as to make its Total Elevation *twenty-four Foot*, or *four Fathoms* compleat.

Or, be the Tide, in its Passage between *Brest* and *Kingsale*, advanced to what other determinate Height soever; yet all the several Floods of our *Irish* and *English Channels*, from *Dublin* to *Hull*; as also those of *France* and *Flanders*, from *Brest* to *Amsterdam*, must depend upon it as their *common Source*; so as to owe their Rise *above* it, either to the advantageous Reception into their *Ports*, or to the favourable Conveyance of their *Channels*, thither; so as to mount some of 'em *ordinarily*, to *thirty* and *forty Foot*; and others *extraordinarily*, to at least *fifty*, *sixty*, and *seventy Foot*: But the Question is, How those *Ports* and *Channels* may be fitly dispos'd for that Purpose?

The *first* advantageous Disposition for a plentiful Flood, is, that the *Mouth* of the *Channel*, which intromits it from the said general Source, be wide enough to fill up the

Ports which receive it, in due Time, before its Reflux takes it off again; or else it falls short of the Height of the common Tide, which leaves the Port so unsupply'd, that it stagnates, in some Measure, into a Lake; that neither rises so high, nor falls so low, as the Sea it self at *Spring-Tides*; while the *Neap-Tides* seem to cease into Calm-water.

Next, to give the said Aperture a considerable Advantage, the *Sides* of the Port which receives the Flood, must mutually incline each towards the other, to contract its Tumour, as it were, *Pyramidically*, from the *Base*, whereby it enters in ample manner, to the *Vertex*, where it is perfected; that the Weight of so much Water, put into Motion, may still push forwards its gradually contracted Stream, with more Violence; to make out in Height, and Speed, what it looseth in Breadth: as it happens in the *Downs*; which lie at above three hundred Leagues distance from the Ocean, and are choaked up with the *Goodwin-Sands*; and withal invert the Current *Westward*, quite contrary to its former Course, thro' the Channel that convey'd it thither; yet the *Bay*, by Vertue of its *Triangular Figure* alone, contracting itself into the Mouth of the *Thames*, sends up the River a considerable Tide, for at least twenty Leagues together.

Thirdly, Because quickness of Motion adds an equivalent Force, proportionably to the Weight of the Water which is moved; and *Projectils*, are inclined to follow their first Direction; every Deflection from it, must turn to the Tide's Disadvantage: Hence it is, that the Mouth of the *Saine*, tho' it adds a Depth
pro-

proportionate to its other Advantages, of *Orifice and Figure*, to furnish Water enough for a protracted Tide ; yet, being entangled by its *Serpentine Windings*, to and fro, it advanceth not up the River above *half* as far, as it doth up *Garrone* upon the *same* Advantages ; finding all along an *opener and straiter Channel*, which carries it up into the Land *one Hundred and twenty Miles*, without any Disturbance.

But, to raise the Tide at *Bristol*, remarkably above *all* the afore-mention'd ; besides the said Advantages of *Breadth, Depth, Figure, and Direction* ; the *Severn-Sea*, which brings it thither, adjoins to the Ocean, and opens *directly* towards it, to receive it in full Force, and give it no *deflecting* Check at its Entrance ; infomuch that the Tide sometimes reacheth *sixty Foot* ; and upon the special Encouragement of a strong *South-west* Wind, it overwhelms the adjacent Country in a *Deluge*, beyond Measure.

Yet, to exalt the Tidal Flood to its *highest* Pitch, after it is contracted to the Half, by our *English Channel*, before it reacheth the *Cape* at *St. Malo's* in *Normandy* ; it is again straitned to the Half, e'er it reacheth the Bottom of *St. Michael's Hill* ; and there, being pent up in a Corner, and put to a peremptory Stop, without any *Inlet* of a River, to take off part of the Tumour, it swells to *twenty Foot* ; the *highest* Tide perhaps, that can be found thro'out the Universe.

Moreover, when *Two* Tides chance to meet, and are united in *One*, the joint Flood becomes exceedingly advanced ; the Speed of their Occurrence one towards the other, be-

The Motion of the Tide,

ing accelerated in a double Proportion to the single Motion of each apart ; as is observ'd in the Congress of the North and South Tides, both in our *Irish Gulph*, at the *Peel* in *Lancashire* ; and at the *Mouth* of *Humber*, in the *German Ocean* ; where they amount to *ten Fathoms*, or *fifty-four Foot* apiece ; tho' it happen at their utmost Distance from the *Atlantick* ; and after the Flux of their Currents be almost spent into *Calm-water* ; yet without the Assistance of the aforesaid Advantages.

In fine, such is the gradual Encrease of the Tidal Tumour, as well in the wide *Ocean*, as in our narrow *Seas*, that one New-Moon Flood, runs thro' all the Diversity I have hitherto described, within the Space of *twenty-four Hours* ; in passing (for Example) from the *Equator* to *St. Malo's* ; insomuch that *six Foot* of Water in the one Place, is advanced to above *sixty Foot* in the other : And whereas it has been observ'd, that the *Equinoctial* Tides do not superadd to the rest, above *six Inches* at the *Line* ; yet at *St. Malo's* they surmount their Fellows at least *five Foot* ; the Product agrees exactly with the former Account, viz. that, as a Tide of *six Foot* there, produced another here of *sixty Foot*, in a *Decuple* Proportion ; so does the *six Inches* superadded make *sixty Inches*, or *five Foot*, which is the Number propos'd.

Thus the Tides are diversified in our *Rivers*, and narrow *Seas*, with an endless Variety, both of Course and Growth successively, according to a regular Order, both of *Time* and *Place* ; with a constant Dependence on the Flux and

Re-



lux of the *Ocean* ; and as received by our
Islands, and *Ports*, with open Arms : But now
 to be treated, as being shut up in such
Enclosures, and *Seas*, as admit of more or fewer
 than ordinary, and sometimes without
 Communication with it whatsoever.

C H A P. V.

*the great Diversity of Tides, in our In-
 and Seas, or Lakes ; and, How they are
 occasion'd.*

Have hitherto consider'd the Course
 of the Tides, and its various Ap-
 pearances, as taking their first Rise,
 from the Moon's Pressure upon
 the Sea, near the Equator ; in-
 much as they affect those Ports and Arms of
 Sea, which have a free Communication
 with the Ocean ; and mostly ebb and flow to-
 gether with it, twice in twenty-four Hours : But,
 now to confine my Discourse to such
 Bodies of Water, as are Seas only by denomi-
 nation, but Lakes in reality, for their little
 Commerce with it ; and with regard to
 the Tides also, which immediately proceed
 from her Pressure and Presence, without any
 Dependence on the Ocean at all.

Now, forasmuch as those Lakes which lie
 wholly sequester'd from the Sea, are differently
 affected by the Tide, from those which en-
 joy a free Communication with it : And a-
 gain, These become as diversly agitated by its

Ti-

The Motion of the Tide,

Tidal Commotion, each according to their *respective* Correspondence with it ; and *more or less*, with regard to the *Number* and *Capacity* of the Passages which joyn 'em together: Hence, for Distinction and Clarity's sake, I begin with those, whose Consideration is most *simple*, and *separate* from the Sea ; and proceed to the Rest, according to the Order of their *Composition*, which have *One*, or *Two* Inlets from the *Ocean* ; and shew how they are affected thereby ; and each in a distinct *Section*.

S E C T. I.

Concerning such Seas, or Lakes, as are wholly separated from the Ocean ; yet sometimes Ebb and Flow, by the Moon's immediate Pressure.

FIRST, the *Caspian Sea* is not obnoxious to any Tidal Commotion, as lying extended from *North* to *South*, athwart the Moon's *Diurnal Course*, which is from *East* to *West* ; so that her Pressure must affect its Surface, much *alike* in all Places at once ; and cannot raise the Tide *more* in one Place than in another : Besides, being so *shallow* towards the *West* Side as scarce to be *Navigable* ; it is not capable to receive a *Counterpoise* of Water, to fetch up the *Eastern* Part, which is much *deeper* ; that the *whole Lake* may *librate reciprocally* both ways ; the *One End* of the Scales, quite *overweighing* the other.

Next, tho' the *Euxine Sea* be of an equal Extent with the *Caspian*, and of a much more
com-

commodious Situation, being stretch'd out from *East to West*, that her Pressure may roll over it successively ; yet it suffers so *small* a Commotion from it, either to set its *Libration* on foot, or to *advance* it gradually, as scarce to render it perceptible ; for want of *inclining Shores*, to contract it into a narrower Compass towards the *East* and *West Ends*, and sharpen it both ways into a Point, as it does in the following Instances.

For, whereas the *Huron-Lake* in *North-America* is of the like Situation, and almost of an equal Extent, with the *aforsaid* ; by being contracted towards the *East End*, into a more *acute Angle* ; it advanceth a Tide to so considerable a Height, that *twice* a Day (by the help of its *Libration*.) it swells the *Canada* more than ordinary, for *five* or *six Leagues* together.

Moreover, the *French* report of the *Upper Lake*, which lies on the *N. West* of this, and falls into the same River ; that notwithstanding it is situated *five hundred Fathoms* above the Superficies of the Sea, and lies at *two hundred and seventy Leagues* distance from it ; yet it Floods to *two, three, and four Foot* in Height ; which plainly shews, that these Tumours proceed absolutely from the *Moon's Pressure*, without the Intermediation of the Ocean to raise 'em by way of *Libration*, at so great a Distance from the Sea, and exalted so many *Fathoms* above it.

And whereas my *Author* adds, that the *Upper Lake* is a *hundred Leagues* in Breadth, and doubtless of a *Length* proportionate ; and finally Remarks, that its Tides advance to the
 Heights

Heights aforeſaid at the Full-Moon, without taking any Notice of the New-Moon at all; he plainly implies, that either happens no Tide of the later Sort; they be of a Size or Number much inferior to the former: And this Reason is affigned for the Diſparity; viz. That, altho' the join'd Pulſes of the Sun and Moon (at her Change) be equivalent to their ſeparate (at her Full) in the Ocean, where the Water's Volubility is ſuch, that 'tis all one whether their Pulſes be once doubly, or twice ſingly, applied, within the Space of twenty-four Hours. Yet in Lakes, wherein, for want of ſufficient Breadth and Depth, the Tidal Turn can not roll to and fro with the ſame Freedom; their Pulſes ought to be repeated twice hourly, (as at her Full) to give every other Vibration a jog, to keep 'em on foot; and not expect 'em to be doubl'd at the twenty-four Hours End, leſt, by ſo long a Forbearance, they grow ſluggiſh and unactive, as, by degrees, wholly to ceaſe.

S E C T. II.

Of Inland Seas, which partake of the Influx of the Ocean by one ſingle Streight, or Paſſage; and how variously they are affected thereby, in reference to the Tide.

AS to thoſe Seas which have a ſingle Inter-
 courſe with the Ocean; the Ballick keeps
 a conſtant Correſpondence of Flux and Reflux
 with

the German Ocean, without any Tidal Influence from it; sending forth a Stream of Water to it in Winter, when the fresh Floods rise above the Level of that Ocean; and drawing it again in Summer, when the rising Heat of the Sun sinks its Superficies much below it.

And, besides, the Gulph lies in too crooked and awkward a Posture, to be wrought upon by a regular Motion, as that of the Tide; and is situated too far North, to be influenced by the Moon's immediate Pressure; and withal remote to the Eastward, and thick-shelved on the West by the Orkney's Islands, to be influenced with a Tide from the Atlantick: on the contrary, the Mediterranean Sea, is situated more advantageously in the said respects; as lying more to the South, in the Tide's way; and being of a compass Figure, is as diversly affected, both by the influx of a Stream from the Ocean, and the impulse of the Tide.

In reference to the former Consideration, it flows down, by the Streight of Gibraltar, a Quantity of Water, without any constant Return; and the Reason is manifest; being most expos'd to be drain'd by the rising Beams of the Sun, by means of its southerly Position, than of any other in Europe: And, on the contrary, being scarcely recruited by the Confluence of fresh Waters, considering the Largeness of its Extension, and vast Tracts of Land, which it covers with its Vapours: as from Spain it receives only the Ebro, which is considerable;
from

from *France* the *Rhosh*; and from *Greece* and *Asia* only the Influx of the *Bosphorus*; which also has its Reflux at the same time; and from the Coast of *Africk* only the *Nile*, which is of any Account; the rest of their Streams (which are almost innumerable) being refunded into the *Indian* and *Atlantick* Oceans, without any other Gullet than this at *Gibraltar* to make Restitution.

And, to consider this *Midland Sea* with regard to the Impression of the Tide; since, as to its Position to the *Westward*, it enjoys a free Communication with the Ocean, to be stirr'd up at every twelve Hours End by the Tidal Influence of the *Atlantick*, after the manner of other Arms of the Sea, which set directly into the *East*: And again, as to its Extent, it stretcheth itself *Eastward* above fifty Degrees, from the said *Streight* up into the *Levant*; and carries along with it a competent Breadth, to resent the Moon's immediate Pressure with a Tidal Commotion, like the *Lakes* aforesaid; which, in accord with her Diurnal Motion, must set into the *West*, in Opposition to the Former.

Now, in regard this *Midland Sea*, (at each End whereof the said two Tides are so differently rais'd,) consists of one entire Body of Water; they must, in some sort, interfere with each other: And again, the Moon makes High-water at *Rhodes*, which lies near the one End of that Sea (as appears by the *Tide-Table*) at her *Southing* there; and finds it again at her *Southing*, on the Road of *Gibraltar*, which is the other End; having pass'd fifty Degrees, or a Quadrant of her Diurnal Circle,
into

into the *West*: Hence the said Tides must so keep Touch with each other, as to *rise* and *fall* by Turns at every *six Hours* End, and compose one *single Motion*; the *whole Body* of *Water Librating* alternately from the one End to the other.

To establish the *Union* of the said *Two Tides* in One, by *Counter-libration*; the *Streight*, which lets in the Former, being of too narrow an *Orifice*, to receive and raise a Tumour sufficient to reach the *Llevant*; especially the Gulph being near *stopt up* in the Middle by *Sicily*; which manifestly *divides* it into *Eastern* and *Western Bays*; which lie not in one *Strait Line*, but disjoin'd and displac'd, each according to the different *Direction* of the *Shores*: Yet the Gulph is of a competent *Capacity* to contain, as it were, *Two Tides* so differently rais'd at both Ends of it at once; which have free *Liberty* left 'em for their *Conjunction*, and fall at a *correspondent Time*, each to *advance* the other, according to its proper and natural *Course*, in reference to their joint *Libration*, quite thro'out the *Mediterranean*; as I have already described.

Besides, the Tides on *both Sides* of their *Axe* rise to near an *equal Height* in the *Eastern* to the *Western Division*: Hence it is, that the Tide rises as high at *Venice* as it doth at *Marseilles*; as also in the *Euripus* as at the Bottom of the *Llevant*; in each reaching about a *Foot*: And more signally to express its Dependence on the *immediate Pressure* of the Moon, it more abounds at the *Full* than at the *Change*; according to the Custom of *other Lakes*, which hold an immediate Correspondence with her Presence: After all, it swells highest where
it

it is *broadest*; and higher on the *North-Side* of the *Gulph* whither it is driven, than on the *South-Side*, where it is taken off by a *Coasting Current* (according to the *Course* of the *Ocean*) into the *South-East Levant*; whence it came.

Now, to take the *Liberty of Speculation* upon the *Tide* in the *Red-Sea*; (having hitherto had a constant *Recourse* to *Sense* and *Experience*, for *Matter of Fact* in other Places) and to argue from *Parity of Reason*; altho' it consists of a *long and narrow Body of Water*, continued by a *Streight* to the *East-Indian Ocean* (much like the *Mediterranean* by that at *Gibraltar*) which is almost choak'd up by an *Island*, which *obstructs* its free *Communication* with that *Sea*; yet it has a *competent Tide* by the *Assistance* of the *Moon's immediate Pressure*; lying stretch'd out, for near *twenty Degrees*, from *South-East* to *North-West*; in the most advantageous *Posture* for the *Moon* to affect it at the *South-East End* first, at her *Rising*; and thence to push the *Tide* forward gradually towards the *North* and *West*, upon her *Advance* to the *Meridian*; and as opportunely to let it fall back again *Eastwardly*, at her *Declination* into the *West*.

S E C T. III.

of Gulphs or Lakes, which, by receiving
Tides thro' several Channels, either add
abstract from their accustomed Number, in
our Seas.

NCE amongst all the Diversity of Tides,
which I have yet discours'd of, either in
the ocean itself, or our narrow Seas, High-
er does regularly affect the same Place,
in twelve Hours: It now falls of course to
enquire, How it come to pass, that one and
the same Tide sometimes flows off, and se-
veral distinct Tides seldom more than twice in twen-
ty Hours: And to produce Instances re-
spective for that purpose,

First, It is observable, that irregular preter-
natural Tides (whether by Excess or De-
ficiency) affect only such Gulphs or Lakes, as are
situated between two Seas; and those of the
former Sort, which exceed in Number, are
occasion'd by the Division of one and the
same Tide into several Streams, by different
Channels, conveying 'em thither at diverse
times; where, notwithstanding their Divi-
sion, if they chance to arrive both at once,
compose but one regular Tide, at their
conjunction; as plainly appears in our Irish Gulph,
where our North and South Channel meet, and
seldom re-unite their divided Floods into
one, and alike communicate it to all the
adjacent Rivers around the Shore.

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But,

But, in case the said divided Floods reach not the *Bottom* of the *Irish Gulph*, at the *same Time*; as is observ'd of the *biggest Equinoctial Tides*, when that Part which comes from the *South*, is driven thither *over-hastily* by a brisk *South-west Wind*, standing full into the Mouth of *St. George's Channel*; before the other Part can come up out of the *North* to join it, (the *same South-west Wind* setting against it;) they become *supernumerary*, as well in the *River Lune*, as in the *Gulph* itself; which, the *former Flood* (coming sooner than ordinary) having fill'd with an *unusual Speed*, retreats; and the *Later*, finding the Water fall'n five or six Feet, *re-advanceth* it as much higher than it was before; making *Two distinct Floods* in *three Hours Space*, contrary to the Custom of the *same Winds and Tides* in other Places.

Two New Tides that hap'n'd in the *said Gulph*, the *Former* in *October*, and the *Later* in *March, 1710*, were *remarkable Instances* of this *Truth*; in coming an *Hour and Half* sooner to the *Lancaster Sands*, by the *South Channel*, than they were expected; and rising *higher* than was usual, being *hurried thither* by *boisterous South-westerly Winds*; and both fell, for half an *Hour*, to near *Half-Tide*; and then rose again, at the coming up of the *North Tide*, by the *other Channel*, five or six Feet *higher* than before; and continued *half an Hour longer* than ordinary, before they went off again; the *North Tide* having been so much retarded, by the *South-westerly Wind* from that adverse Quarter.

For *Ireland*, lying interpos'd between the *Ocean* and the *said Gulph*, where those *Tides* abound; and being separated on the *South*

Supernumerary or Defective. 151

from *Wales*, and on the *North-East* from *Land*, divides every Flood into *Two*, as they pass thro' their several Channels thither; and, if they arrive (as they commonly do) at one and the same Time, they are again re-united into one Regular Tide; or else, if the one be hasten'd, and the other retarded by the same Wind, or by any other Accident, they remain still divided into two Irregular Tides; 'till their Return from thence into the Sea, whence they came.

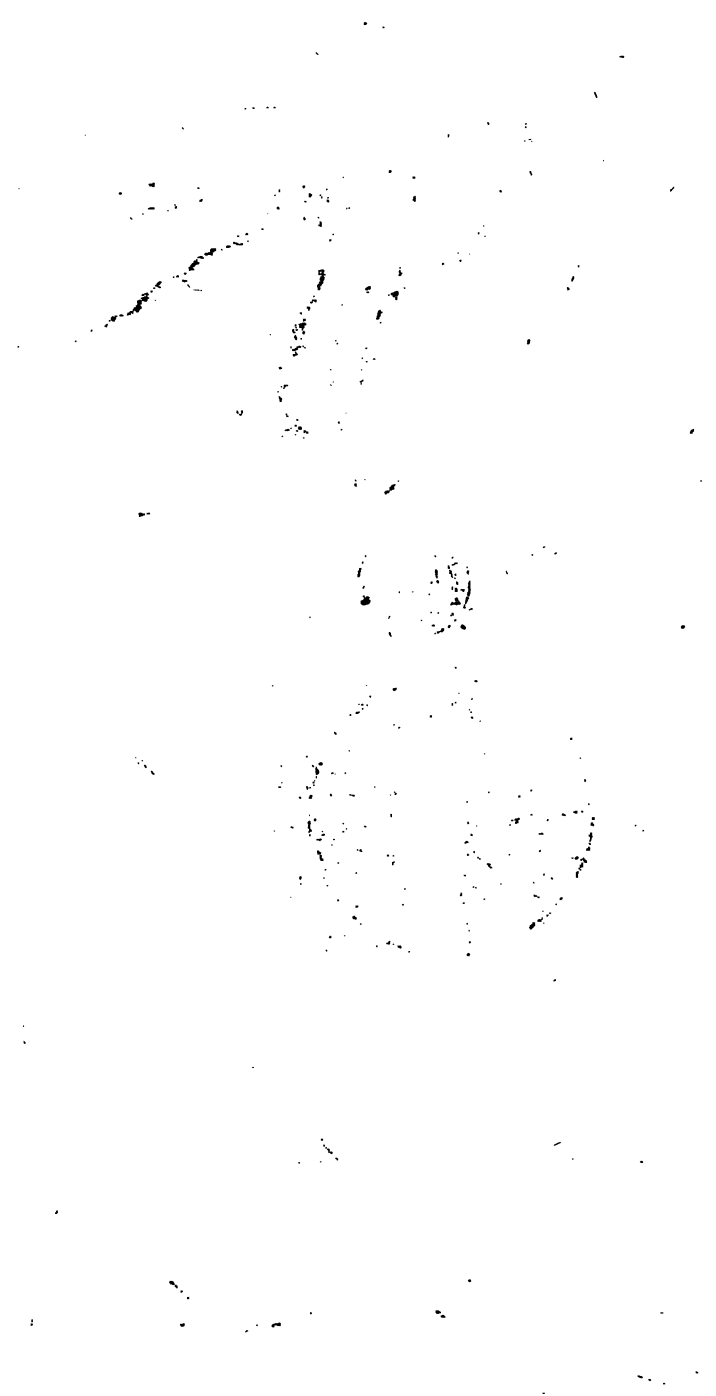
Now, in regard the Isle of *Walney* is alike expos'd between the said Gulph and the Channel (or Race) which separates it from *Ferry-bridge* in *Lancashire*; in case the Tide be Regular, it will as to swell up the whole Gulph jointly at the same Time; it must enter the said *Walney Channel* at both Ends, at the same Instant; and consequently, their divided Streams meet in the middle of the Race, and re-unite still into one Regular Flood, as was before: But contrariwise, if the North and South Floods remain divided in the Gulph itself; they subdivide here into Four in twelve Hours; and if that Tempest, which first separates 'em, continues so long; they become again redoubled into Eight in twenty-four Hours, by a repeated Succession.

Because, *Walney* lying at the Bottom of the Gulph, and at an equal Distance from the Mouths of the said Channels; its Race stretching itself seven Miles in Length, and situated directly North and South; each Tide must respectively enter it sooner at the one End, than at the other; so, as to make each its Fluxes in itself, apart; that every irregular Tide, whether from the North or South, may make

Two of each Sort in this Gullet, for One in the Gulph itself: So that, when One Tide of the Ocean becomes Two in the said Gulph; those Two must be redoubled, in the Walney Race, into Four within the Space of twelve Hours; and these into Eight in twenty-four Hours, the same Means being repeated; as is manifest.

Hence plainly appears, how Tides may be multiply'd above their usual Number, in some Seas: Now, to shew how they fall short of their common Account in others; it was farther observ'd, that, altho' the said Gulph sent *Two* distinct Floods up *Lune*, as far as *Lancaster*; for One receiv'd from the Ocean by different Channels; yet at the same Time, those *Two* Floods re-united into One, in *Marshey* at *Liverpool*; notwithstanding both Rivers had an immediate Communication with the Gulph itself; because they comply'd not alike with its Tidal Agitation: For, the *Former* having a wide Aperture, and but a narrow Channel, was quickly fill'd by the *South Tide*, and soon emptied together with the Gulph: Whereas the *Later*, having contrariwise a large Pool to be fill'd, and but a strait Gullet to let it off again, cou'd not dispatch its Work, before the *North Flood* came up, to re-join 'em both into one single Tide; which stood to its full Height, with scarce any sensible Diminution, for near *two Hours* together.

Thus one regular Tide of the Ocean, by passing thro' several Channels, with unequal Speed into the *Irish Gulph*, became *Two* irregular ones. Again, each of those *Two*, by entering *Walney*



e differently, were re-doubled into *Four*; the contrariwise, by *hasting too quickly*, the after the other, into the Port at *Liverpool*, they re-united again into one, in *twelve* Space; and by the *same Means* repeated, *would have re-doubled in twenty-four Hours*, *Number Four into Eight*, at *Walney*; and *into Two at Liverpool*: And moreover, the *R. Marsey* been capable to contain, and *uce these Two* last into *One*, at *twelve Miles* *ance up the River*; there had been but *One* *le at Warrington*, in *twenty-four Hours*, for *be at Walney*; as is manifest.

Now, this being the present Condition of Tide in reference to the *Euripus*, where it *vs Eight times*, for *Once in the Port at Tun-* : I am to shew how it is *multiply'd* in the *ner*, by the Interposition of *one Island behind* *her*; and in the *Later*, how it is reduc'd to *w*, by the Position of *Ports*, lying in the *consequent Order*; and declare expressly the *ner*, how *both* are effected in the *Three* *ing Sections*.

SECT. IV.

the supernumerary Tides, in the Euripus; and their Analogy with those which sometimes happen in our Irish Sea.

N that *Gulph* which lies between *England* and *Ireland*, which hath *North-Wales* on the *th*, and on the *North Galloway in Scotland*;

it is observ'd, that, as One Tide in the Ocean, being divided into several Streams successively convey'd thither, makes Two Floods; and these, being subdivided by the Interposition of *Walney Island*, seem to become Four Floods in twelve Hours, and Eight in twenty-four Hours, within the Streight between it and *Furness* in *Lancashire*: So One Tidal Tumour in the *Mediterranean Sea*, in the same Spaces of Time, raiseth Two in the *Archipelago*; and Two here advance Four in the *Euripus*, by the Interposition of *Candia* and the *Negroponte*: Of which, that I may deliver the Particulars after a more special Manner, in the following Sections; let us first take a View of its common

DESCRIPTION, Viz.

“ The *EURIPUS* is an Arm of the Sea,
 “ between *Achaia* and the *Negroponte*; so narrow
 “ about the Middle of it, that it is pass'd
 “ over by a *Bridge*: where the Streight is
 “ broader, the Tides are more regular and constant;
 “ for, in the narrowest Part, they are regular
 “ three Days before the *Change*, and eight Days
 “ after; and one Day before the *Full*, and six Days
 “ after, and the rest irregular: During which Time,
 “ the *Euripus* Ebbs and Flows 11, 12, 13, or 14 times
 “ in twenty-four Hours; but during their regular
 “ Motion, they flow as other Seas.

“ There are also particular Differences, between
 “ the Tides of the *Euripus*, and those of the Ocean:
 “ First, The Water never rises above a Foot high,
 “ and that very rarely too; whereas in many Parts
 “ of the Ocean, it rises

“ rises *twenty-four Cubits*: Secondly, That, in
 “ the Ocean the Water falls, when it ebbs into
 “ the Sea; and rises, when it flows towards
 “ the Shore: Whereas the *Euripus* rises, when
 “ the Water ebbs towards the Islands of the
 “ Archipelago, where the Sea is broadest; and
 “ rises when the Water ebbs towards *Thessaly*
 “ into the Channel of *Salonichi*; altho’ it is ob-
 “ serv’d, that at High-water the Water stands
 “ still, without moving one way or other for
 “ an Hour, or half an Hour together: But the
 reason of this, no Man (*says the Author*) can
 unriddle.

Now, to draw a Parallel between the Situa-
 tion of the *Gulph* which divides *Ireland* from
England, as the *Archipelago* does *Candia* from
Greece, on the one Part; and of the Channel
 which separates *Walney* from *Furness*, as the
Euripus does the *Negroponte* from *Achaia*, on
 the other; in reference to the Tides produ-
 ced in all Four Places: Since they lie all open
 at both Ends, to receive their opposite Floods,
 either successively, or both at once: As often as
 they mutually occur in the Middle of their
 Channels, they unite each Two into One, at
 their Congress in the *Archipelago*; and re-unite
 again in the *Euripus*; as I have shewn they do
 in the *Irish Gulph*, and *Walney Race*; and have
 one single Tide apiece, in twelve Hours Space,
 as regularly as in the Ocean itself and *Mediterranean Sea*, whereon they depend.

On the contrary, at the Seasons of their
 Irregularity, when the said counterposing
 Floods arrive successively, one after the other;
 so as to make distinct Tides, at the Place First

design'd for their Occourse; their several Streams must be subdivided at the Second: Hence, as every single Tide of the Ocean, divided by the Interposition of Ireland into Two distinct Tides in the said Gulph, becomes subdivided by Walney Race into Four: So every Tidal Tumour of the Mediterranean Sea, being first divided by Candia, becomes Two in the Archipelago; so afterwards subdivided by the Negropont, it is made Four in the Euripus, within the Space of twelve Hours; and in twenty-four Hours, they double that Number.

Again, whereas the Ocean's Tide requir'd a S. West Wind, to carry the one Part of it down into the Gulph, before the other cou'd arrive from the N. West, to keep their Floods distinct; and each of these were differently directed into their respective Ends of Walney Race, to transmit their Floods into 'em at several times: In lieu thereof, it is observable, that the Mediterranean Tumour, in passing from the Streight of Gibraltar to the Levant, deflects that Part of it into the Channel which severs Candia from Morea; at a competent Distance of Time and Place, from the other which parts it from Rhodes; for their Two Streams to produce, each a distinct Tumour in the Archipelago: And these, taking as different Courses towards the Euripian Streight, the one being so much shorter and more direct than the other, that their different Allowances of Time is doubl'd before they reach it; to subdivide their Tumours here, and subdistinguish 'em each apart, no less than those did before in the Archipelago, without interfering in any respect with one another.

And

And if those *North* and *South* Streams, which flow from the *Ocean* into the *Irish Gulph*, seem to come thither as it were *by Pairs*; and haste too soon the one after the other, to make distinct Tides after an Hour and a half's Ebb, either there, or in *Walney Race*; the *Mediterranean Flood*, to make amends as to that Part of it which first enters the *Archipelago*, finds a shorter and readier Passage at the *West End* of *Candia*; while the Remainder traverseth the *South Coast* of the *Island*, above thirty Leagues out of its way to the *Eastward*, before it descends into the said Sea; and every Flood here, being subdivided by the *Negroponte*; that Subdivision, which enters the *Euripian Gulph* at the *South End*, finds as short and direct a Passage, as before; while the other has the whole Length of the *Negroponte* to pass, and to repass the half Way back again, by a narrow and difficult Gullet, before it reaches the *Streight*; to rejoin its *Compart*, which was retired before it advanced thither; so as to have a full Allowance of Time, to make a fresh Tide at every three Hours End.

And, forasmuch as the Tidal Tumours in the *Archipelago* are scarce perceptible; yet their depending Floods are distinct enough in the *Euripus*, as entering alternately, at the Distance of the Time aforesaid: That from the *South*, by a Channel of a wide Aperture, which contracts it gradually almost into a Point, to give it Height in the *Streight*; while the other from the *North* makes use of the like Advantage, to raise its Water above the *Archipelago*, their common Source: And, on the contrary, tho' the Tides run very high in the *Irish*

Irish Gulph, as being influenced immediately by the *Ocean*; yet they are scarce distinguishable in *Walney Race*, because of the *Shortness* of its Channel, and the sudden *Hurry* of its Streams thro' it; which, for *Number* of Fluxes and Refluxes, are the same with those of the *Euripus*, tho' without the like *Tidal-Distinction*.

Especially, in regard the said *Irregularity* proceeds, in the *Irish Gulph*, from an excess of Flood hasten'd by *Storm*; which never happens, but at *Change* and *Full*, and mostly when the *Moon* is at her *Equinox*: But the *Multiplicity* of the Tides in the *Euripus*, falls constantly at her *Wane*, thro' *Defect* of Water, when the *South Tide* cannot hold out its Course, till the *North Flood* comes up to join it: So that both fall back irregularly before their Union; which happens periodically twice every Month, and for several Days together: Whereas in our *Western Gulph*, those *Spring-Tides* are separated by *Anticipation*, and only accidentally, but twice or thrice a Year, when the Wind proves favourable to the one Side, and adverse to another.

Yet, whether the Tide's *Irregularity* proceeds from an *Excess* or *Defect* of Water; their *Regularity* still supposeth a perfect *Re-union* of the Tide, to succeed in the same Place, after every *Separation*: And as often as several Places depend each on other; the *Re-union* in the later Place, still supposeth an *Union* of the Tides in the former: Hence, the regular Tides in the *Euripus*, must presuppose the *Union* of two preceding Tumours, in the *Archipelago*; and this to be caused at the *Full* and *Change*,
when

on both the Sun's and Moon's Concurrence, *outh*ing upon the *Levant*, falls in with the *an*; and more especially at the *Change*, *n* they *South* there both at once, jointly to *orce* their Meridian Pressure.

and the better to unite Two of those Tu-
ars into One, when the Pressure is consi-
ably encreased, it stirs up a *Libration* in the
ant, from *South* to *North*, transverse to that
ch is deriv'd from the Ocean, which is
a *West* to *East*: And this moving alternate-
backward and forward, all at once, is apt
tard the first Tumour, and hasten the later,
he same *Undulation*; and these so united
v enabled to raise a correspondent Tide in
Euripus, to continue at the same Height
in Hour together: Whereas the irregular
ided Floods, rise and fall at the half Hour's
without the mutual Support of each o-

nd, forasmuch as the Channel to the
ward of *Candia*, affords a shorter and
ier Passage, and points more directly to-
ds the *Euripus*, to transmit a stronger and
ier Flood into the *Archipelago*; the other,
ch traverseth the Length of that Island, be-
it diverts into it, can only be a slow and
e one on that Account: Yet the Moon's
bing upon the Mouth of the *Eastern* Chan-
, and enforcing her rising Pressure gradual-
hereon, from the *S. East* *Levant* for one hun-
d and fifty Leagues together, must suffice to
alize its Flood with the former, in the *Ar-
pelago*; and consequently to raise four equal
des in the *Euripus*, in the first twelve Hours
her Presence, to enforce it.

Yet

Irregularity of some Tides,

Yet in the next twelve Hours, after her Departure from our Hemisphere, that secondary deflected Arm of the Mediterranean Tide, being deprived of her present Assistance, is thereby disabled for raising its Tumour in the Archipelago, to its former Height; Again, this Tumour being subdivided by the interpoling Negroponte, before it enters the Euripus; hence that Branch of it, which deflecteth again to the Northward, and is to return into the South, by the aforesaid narrow reflex'd Gullet, must languish away into Faint, and become imperceptible, before it reach the Streights itself. So that these Three remaining Tides, being added to the other Four, compleat the Number of Seven; which are all that can possibly be incident to the Euripus, according to the vulgar Account.

So close does the Parallel between the Two Seas, and their respective Tides (all Circumstances duly considered), hold to conclude, that Two regular Floods, and Seven irregular ones, are incident to the Euripus, at their several Seasons; tho' caused originally, by the regular Impulse of the Mediterranean Sea, which flows but twice in twenty-four Hours: And the great Diversity of the Means WHEREBY, and of the Manner HOW, the same Work is differently wrought; is so far from lessning the Validity, or obscuring the Evidence of the Effect, on either Part; that their Differences (as Light and Darkness counterpos'd) at once mutually confirm, and illustrate each other to Perfection: Let us now accord the

And Diversity of the *Euripian* Tides amongst themselves, with those of *other Seas*.

S E C T. V.

Observations upon the Diversity of Tides, in the Euripus ; and how consequent it is to my present Discourse, of the Tides in other Seas.

HAVING already stated the Number of the Tides, in the *Euripus*, according to the Evidence of Reason, and Experience ; it now follows of course to enquire into the *Means*, and *Manner* of their Diversity ; with due Respect to the *Terms*, and *Tenour* of its former Description ; to shew how it squares with the Principles, I have already laid ; and the Method I have follow'd thro'out my Discourse upon the same Subject.

First, It is observ'd, That the Tides are regular about the *Full* and *Change* of the Moon, and become irregular at her *Wane* ; because at her *Change* and *Full*, when they flow in ample manner, the *South-Tide* becomes both quicker, and lasteth longer ; so as to hold out Flowing, till the *North-Tide* can arrive by the other Channel, to join it ; as well in the *Archipelago*, as in the Streight of the *Euripus* ; in both which Places, they make but One regular Tide, consequent to the *Mediterranean* ; whereas in her *Wane*, for want of a sufficient Supply of Water, the former Tide retires, before the later can come up to join it ; so as to make

Two

Two separate Tides, in the *Archipelago*; which being again subdivided in the *Euripus*, must make Four irregular Tides; as is manifest.

Secondly, Their Regularity continues four Days longer at the *Change*, than at the *Full*; which must needs proceed from a greater Depression made upon the Sea, by the joint Cooperation of the Sun's Light, and Heat, with her Pressure at their *Conjunction*, than at their *Opposition*; when their Forces are separated, and cannot at once affect the *Mediterranean*.

Thirdly, The Terms of their Regularity begin but two or three Days before the *Change*, and *Full*, when the Moon's Influence is at its Height; and yet continue for six, or eight Days afterwards; which plainly shews, that the *Mediterranean* Tides, are not forced to a competent Height, point blank, by the direct Impulse of the Moon; or by the first Pulse of the *Atlantick* Flood, thro' the *Streights*; but are rais'd only by Degrees, with the Assistance of *Reciprocal* Librations; which find the Sea all along, from thence to the *Negroponte*, more quiet and compos'd; and so they must be often repeated, before its Motion be considerably heighten'd, at so great a Distance; which again requires a proportionable Time after, to abate again into its former Irregularity.

Fourthly, The Water in the *Euripus*, never rises above a Foot, and that very rarely too; whereas in many Ports of the *Ocean*, it rises twenty-four Cubits; because those Ports receive their Tides, with Mouths wide open, immediately from the *Ocean*, their common Source: But, on the contrary, the *Euripus* derives its Flood, in part from the *Atlantick*, thro' the

narrow Gullet at Gibraltar ; and down the Mediterranean, for three hundred Leagues together : And in part from the Moon's Impulse upon that Sea, where it wants the Breadth, and Depth of the Ocean, to raise its Undulations : So that 'tis no wonder, if every Cubit languisheth into half an Inch, before it affect the Negroponte, at so vast a Distance, and Disadvantage.

Fifthly, In the Ocean the Water falls, when it ebbs into the Sea ; and rises, when it rowls towards the Shore ; whereas the Euripus rises, when the Water ebbs, either towards the Sea or Shore, indifferently ; and can do no less, being a Thorowfare Channel for Two opposite Tides, to pass and repass thro' the Streight ; where they never arrive exactly at the same Time ; and that which advances first, mostly retires, before the other attain to its full Height : So that the one Flows, while the other Ebbs, either towards the Land, or Sea, respectively.

Sixthly, It is observ'd, that at High-water the Water stands still, without moving any way for an Hour, or half an Hour, together ; That is to say, the Water stands still only for half an Hour, when the Tides are irregular ; one Tide still returning, before the other be advanc'd to join and support it : But if they be regular, the supervening Tide always keep the other up, at least half an Hour longer : As when the South and North Atlantick Tides meet upon the Equator ; the Former, which arrives an Hour and half sooner, is kept up by the Later, to its full Height, for near three Hours together.

Lastly,

Lastly, During the Time of their irregularity, the *Euripus* ebbs and flows 11, 12, 13, or 14 times in twenty-four Hours; doubtless, as depending upon the various Influence of the Sun and Moon; according to their different Aspects, between their Conjunction and Opposition; besides the Change of their Latitude, and Variety of Distance from the Earth; which must make as various Tides, both for Number and Proportion.

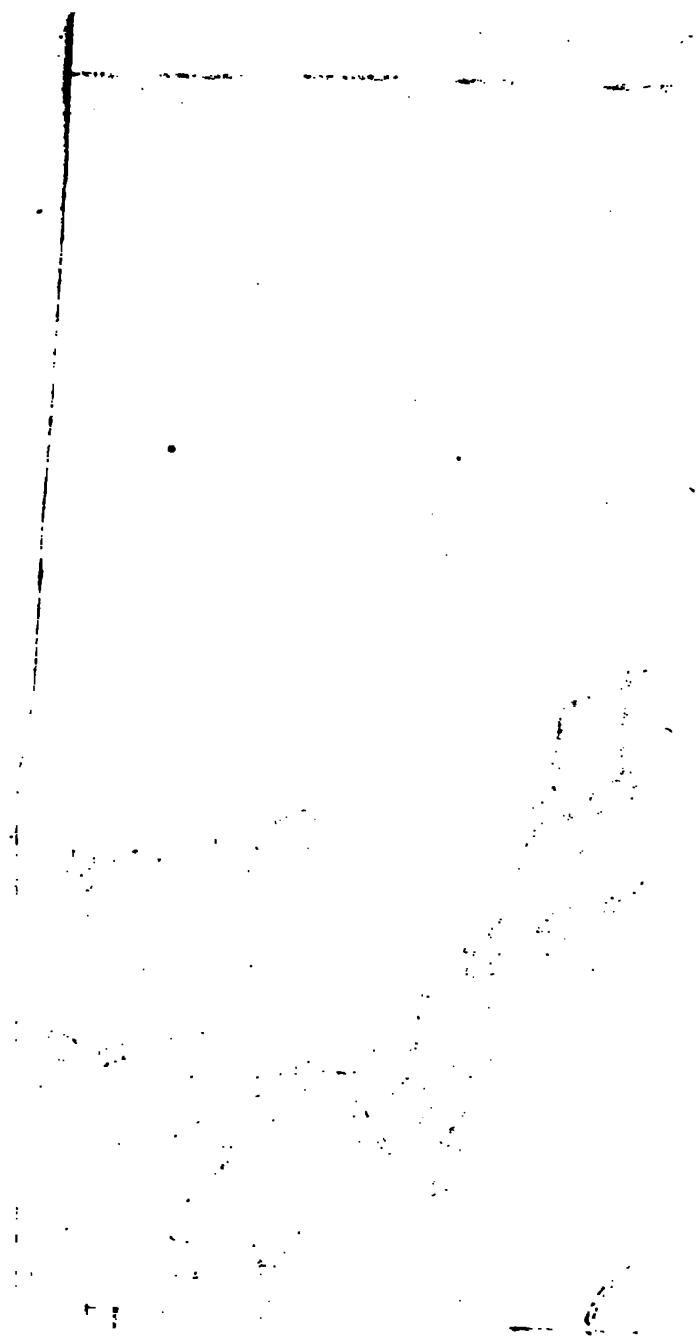
And it is no wonder, that this Irregularity shou'd rather appear in the Streight of the *Euripus*, than in any other Sea, being so contriv'd by the Great Architect of the Universe; as if on purpose, to hold the Ballance of the Two opposite Gulphs, with so equal a Hand, as to turn the Scales, upon every Inch of Advantage, on either Part, and is placed so commodiously, on the Backside of *Achaia*, as to weigh the various Tumours of the Archipelago, upon the least Commotion, which way soever they approach it, as they pass by; while the Tide, after so long a Course, as from the Streight of Gibraltar, is in so faint and languishing a Condition, (as in no other Sea;) to be scarce perceptible.



§.

Remarks upon the Observations aforesaid.

To sum up the whole Account I have given, of the Tides of the *Euripus*, and the Reasons for them, in reference to those I have already observ'd in the Ocean, and discuss'd thro'out my precedent Discourse; in order to confirm them,
by



a Rehearsal of some Passages here and there, and *comparing* them together.

First, It is to be noted, that the *Mediterranean* Tide, according to its *common* and diurnal Course, always produceth *irregular* Tides at the *Euripus*; as falling short of a *competent* Height, either *there*, or 'in the *Archipelago*; as we have all along taken notice.

2dly, That, to reach its *regular* Height, its *instructed* Course is advanced, by the joint concurrence of the Sun's Influence (as in the *can*) with the Pressure of the Moon; both on the *Equator* *mediately*, and *immediately* on the *Levant*; as hap'ning constantly about her *Change* and *Full*, when they concur as aforesaid: Yet,

3dly, Their Influence works *more effectually* at their *Conjunction*, in the *Presence* of them, than at their *Opposition*; when she is absent from our Hemisphere; when the *single* impulse of the *Atlantick* must do the Work; hence, there are more *regular* Floods at the *Change*, than at the *Full*.

4thly, The *Term* of their *Regularity*, beginning but *two* or *three* Days before the *Change*, and *Full*, when the Pressure is *greatest*; and, continuing *six*, or *eight* Days after; plainly demonstrates, That the Tides are *not rais'd* to that Height, neither *here*, nor in the *Ocean*, to the meer Dint of their Impulses; but as *assisted* by repeated *Librations*, which are *neither soon rais'd*, nor *soon allay'd*.

5thly, Notwithstanding all those *Advances*, even the *Regular* Tides never rise above *Foot* in Height, for want of the *Sea-room* in the *Ocean*, to rowl in *Latitude* from *Pole* to

Pole; or in *Longitude*, from the *Streights Mouth*, to the *Bottom of the Levant*; without being interrupted by the *Interposition of Sicily*, in the very *Middle of its Course*; where the awkward *Devarication of the intervening Passage*, breaks its *Force* to almost nothing, before it can reach from one *End of the Mediterranean* to the other.

6tibly, Nor were it possible, that the Tide shou'd be kept on foot, for *six hundred Leagues* together, by the *single Impulse of so narrow a Gullet*, the one way; did not the *Moon's Influence*, alternately push it again the other, at least once in every *twenty-four Hours*; which it constantly does, from her *Rising till her Setting*, at the *Road of Gibraltar*: Much less cou'd it raise the Tide higher at *Venice*, beyond *Sicily*, which *obstructs its Course*; than at *Marseilles*, on this Side that *Island*; did not the *Moon influence it as powerfully on the East Side*, as the *Streights do on the West*; and this also not by *Attraction*, but by *Pressure*; since the Tide is *driven all along, upon the European Coast*, and not *drawn towards the African*; and is rais'd to the *greatest Height*, where the Sea is *broadest*; as between the *Bottom of the Venetian Gulph*, where the Tide *most abounds*; and the *African Shore*, where it is scarce perceiv'd at all.

Finally, Nor cou'd the *Variety of Flux*, and *Reflux* be produc'd, without the *special Concurrence of the Sea's Situation*, for that purpose. As, to *divide One Mediterranean Flood* into *Two*, by a *Two-fold Passage* into the *Archipelago*; and again to *subdivide these Two* into *Four*, by the *same Means* in the *Euripus*, while the

the Water keeps *low*: And, on the contrary, on its *Rising*, to rejoin those *Four* into *Two*, and re-unite those *Two* into *One*, after their separation.

So little does the *Diversity* of Tides, found in our *narrow* and *shallow Seas*; and much less the various Fluxes, and Reflexes of the descending *Rivers*, argue any *Irregularity* of Motion in the *Ocean* itself; or the least *Deviation* from the Intercourse of the Sun, and Moon, which I have *already* described; but meerly proceeds from some *Inequality* of the Passages and Shores, which *hastens* or *retards* their Motion; or Disproportion in the *Situation* of the Place, that gives them as *different* a Reception.

Nay the *Euripus*, which for its *Multiplicity* and *Variety* of Tides, has been hitherto an extricable *Riddle*, to puzzle and perplex all Mankind; is so far from laying any *new Difficulty* in our Way; That, when its *Situation*, and the Motions of the Tide consequent thereto, are duly consider'd; it proves to be a very favourable and explanatory *Instance* and *Example* of what I have discours'd upon this Matter, in other Places.

S E C T. VI.

Of the small Number of Tides in some other Places; and Why, in the Port at Tunkin, there happens but one Flood in twenty-four Hours, and twice each Month, no Tide at all.

SINCE the Plurality of Tides, above the usual Stint (as I have shewn) proceeds from the like Number of Channels, dividing them as they successively pass into the same Gulph, or Port: And, on the contrary, their Paucity is occasion'd by as many Gulphs, still contracting distinct Tides, and those also deriv'd from different Seas, into half their Number: And since I have made it plain, how the common Tides, which constantly affect other Seas, but twice in twenty-four Hours, become doubled in the Irish Gulph, and redoubl'd in the Euripus: It now remains, on the contrary, to produce a Parallel Instance, wherein Four distinct Floods, and those also proceeding from diverse Seas, are daily join'd into Two, and these subjoin'd at last into One; and this also is sometimes intermitted: And in order to shew, by what Means it is effected; take here, what is reported of the Port at Tunkin in China, for Matter of Fact:

" In the said Port, there is but one Flood
 " and Ebb in twenty-four Hours; and twice
 " in each Month, (*viz.* when the Moon is
 " near the Equinox) there is no Tide at all
 " but the Water is stagnant; but with the
 " Moon's Declination there begins a Tide,
 " which

“ which is *greater* when she is in the *Tropical*
 “ Signs ; only with this difference, that
 “ when the Moon is to the *Norward* of the
 “ *Equinoctial*, it flows when she is *above* the
 “ *Earth*, and ebbs when she is *under* it ; so,
 “ as to make High-water at Moon’s *Setting*,
 “ and Low-water at Moon’s *Rising* : But, on
 “ the contrary, the Moon’s being to the
 “ *Southward*, makes High-water at *Rising*,
 “ and Low at *Setting* ; it Ebbing all the
 “ Time, she is *above* the *Horizon* ; as appears
 “ more at large, *Philos. Transact.* Numb.
 “ 162.

To disclose the *Cause* of this odd Appearance of the Tide at *Tunkin*, with regard to what happens of the same Nature in the *Irish Gulph* and the *Euripus* ; it is to be noted, that these *three* Arms of the Sea are stretch’d out from *North* to *South*, and lie open at *both Ends*, to receive their respective Floods ; which here at *Tunkin*, are propagated from *different* Seas ; by the *North Channel* from the *Pacifick*, and on the *South* from the *Indian Ocean* : But what is more *remarkable* ; at the *Middle* of the *Gulph* (where these Floods meet), lies open a *Bay* of a vast *Extent*, to receive ’em, and to carry their Streams to the *Port* ; where they make but *one* Flood and Ebb in *twenty four Hours* ; and the Manner how this is effected, is what I now undertake to describe.

As for the *Manner* of their Concurrence, instead of hitting an exact Time for their Conjunction, the *South* Tides arrive not ’till *six Hours* after those out of the *North* ; the *Indian*

respective North and South-Passages,
Entrance into it ; and come no o
Twice, within the Space of twenty-f
they have twelve Hours apiece, to n
Fluxes and Reflexes, forward and b
as compleat as in other Seas.

But all Four Floods, when they
Middle of the Gulph, being of cour
into the Mouth of the Bay, succ
every six Hours End ; and it being a
a vast Extent, and horizontally Level ;
curing Ebbs cannot make so quick
out of it, as not to stagnate : Be
Flood still overtaking another, e'er
spent, the Water in the Bay must
while, and swell up a Tumour in
which lies in the Bottom of it, 'till i
determinate Height, which cannot be
and must stand mounted to that advan
as long as their united Forces conti
to support it alike all the while : as i

o over-power their Fellows; this surpassing Height of Water, must ebb off again on the weaker Side, in as long a Time as it was in rising; That is to say, in twelve Hours apiece: So that 22 four concur to make but one Flood and Ebb in twenty-four Hours; as is manifest.

Now, to assign which two Tides must be predominant over the other, with regard to the Situation of the said Port: Since it lies eighteen Degrees to the North of the Equator; the North Tide, must needs be Superior: Again, for-much as the Primary Tides must exceed the Secondary Ones, the Primary North-Tide must be Supream: And, seeing the Port lies between the Tropicks, the said North-Tide must make High-water at the Moon's Setting (as it actually happens at Tunkin), as being the Result of the Ebb which she had caused by her reflux, at her Southing upon the same Meridian.

Again, the Secondary North-Tide must needs exceed any that can be rais'd in the South; in regard the Pacifick Ocean, whence it is propagated, coasts the Gulph all along upon its North, and East Quarters; where it finds Store of Inlets to receive it, which are both short and direct: Whereas those from the Indian Sea come farther off; and, having the crooked Windings of the Molucca Streights to traverse, are half spent before they arrive: Besides, this Secondary Tide, hap'ning twelve Hours after its Primary One, falls at a right Time to work the same Effect in the Port, by the Concurrence of its Associate out of the

Irregularity of some Tides,

South, at the *Rising* of the Moon, that its Competitor did at *Setting*.

Now, to state the respective *Efficacy* of their *mutual Concurrences*, as they make one circular Revolution, according to their *six hourly Succession*, as I have already described; it is remarkable, that, whereas the *Primary North-Tide* has but the *Secondary One* out of the *South* (which is the last and *weakest* of that Order) for its Partner: This *Secondary North One*, has the *Primary One* out of the *South* to precede it, and fill the Bay pretty full, before it arrive; to raise it at least to an *equal Pitch*, with its Competitor; that both jointly may hold the *Water's Equilibrium steady*, and the Tide in suspense; while the Moon stands Neuter, near the *Equinoctial*; as it actually happens in the said Port twice every Month.

But upon her *Declination* the Tide rises; and if she decline towards the *Norward*, the *Primary Tide*, on that Side of the Equator, being more enforced by her Pressure, makes High-water at her *Setting*: But, repassing the *Equinoctial Southward*, the *Secondary North Tide* (which hap'neth at the twelve Hours End) thro' the more favourable Assistance she gives the *Primary South Tide*, its Associate, on the contrary, shifts the Tide from her *Setting* to her *Rising*: And the nearer she approaches to either *Tropick*, the respective Tide becomes more advanced; and that One joint Tide, being compos'd of all Four; Two to Flood it up into the Port, and Two to Ebb it out again; each Flux and Reflux must continue twelve Hours apiece; which gives

gives a just and full Account of the *whole* Appearance.

Such have been the *various* Phenomena of the Tide, thro'out the *Ocean*, according to my best *Information*, as I have described; yet *no one* of 'em has thwarted the Doctrine I have deliver'd upon that Subject, in the least: And so much they have been *diversify'd* by the occurring *Coasts* and *Shores*, and their *Inlets* within Land; that, upon sight, they appear'd universally *Anomalous*, in some respect or other; yet still have fairly accorded with the Principles I have here laid, and the Use I have made of 'em: But as for their *Paucity*, or *Plurality* in any Arms of the Sea, I found *none* that appear'd, upon sight, so *odly* extravagant as the *Euripus*, and the *Port at Tunkin*; nor any that prov'd more suited to my Purpose, and *regular*, upon a due *Examen* of all their Circumstances, thro'out the Universe.

S E C T. VII.

Of the various Floods and Currents, found in the Magellanick Streight, of the Bosphorus, and at Gibraltar; Their several Causes; and the Manner how they are occasion'd,

SINCE I have shewn already, what Tides have been occasion'd in the *Gulphs* of several *Seas*, by their Floods passing thither thro' *Streights* and *Passages*, differently affecting them; It now occurs farther to demonstrate,

Various Tides and Currents

monstrate, what Floods and Currents are found in those Streights; when they mediately conjoin as different Seas; as, 1. Either Two several Oceans; 2. Or Two Inland Seas; or else, 3. One of the one Sort with another of the other.

It is generally observ'd, that the Stream which most constantly affects any of those Streights, still descends from a higher Situation to a lower: Hence it is, that the *Anian* and *Molucca Streights*, which, in the North, conjoin the *Pacifick* with the *Tartarian*; and in the South, with the *Indian Ocean*; as also the *Magellanick Frish* does the *Ethiopicke* with the *South Sea*; all three Currents descend Westward, from Oceans rais'd and push'd forward by an Easterly Wind, into a lower Water: As, on the contrary, the Stream, at *Gibraltar*, descends into the *Eastern Mediterranean Sea*, drain'd lower than the *Atlantick Ocean*, by the scorching Beams of the Sun; and the *Bosphorus* descends from the Higher *Euxine* (swell'd with the *Danube*, *Boristhenes*, *Tanais*, &c.) into the *Lower Archipelago*, which receives not a proportionate Recruit.

Now, as to those Streams, or Currents, which are peculiar to the Streights of every Sort; and, for Brevity's sake, to single out One of each Kind, which is most remarkable for the great Diversity of their Floods;

First, The *Magellanick Streight*, which conjoins the *Ethiopicke* and *Pacifick Oceans*, besides its constant Stream into the West, has also a Tide that sets in with it, which rises and falls every

every six Hours, with about twelve Minutes Interval, as in other Seas : And a contrary Tide, from the *Pacifick*, falls into the Mouth of it at the *West End*, which contracts itself narrower towards the *East*, for thirty Leagues together ; 'till the *Gulph* become straitest, and the opposite Floods grow sharpest, when they chance to re-encounter near it.

So that the *Passenger*, to render this *Gulph* *Navigable*, avoids the falling in with their *Occourse*, where the Streight is narrowest ; by taking the *First* of his Tide, to bring the Vessel into it, and carry her thro' it, before she meets with the *Adverse Flood* ; that the Channel becoming re-enlarged, (the One being not too much contracted, nor the Other relax'd,) their occurring Streams may swell up gently into calm and smooth Water : so that, if a brisk Gale favour the Ship's design'd Course, she may bear up against the Stream, either to the *East* or *West*, so as to make the *Voyager's Passage* quick and safe : Insomuch that the good Success of some, who *Timed* and *Tided* the Shooting this *Gulph* aright, have discredited the dismal Reports of others, as feigned and fabulous.

But, Mr. *Dampier* found 'em much otherwise ; who tells us, That after his Ship was run into the Mouth of *Le Mair's Streight*, (which is near the *Magellanick*, but much less difficult and dangerous) " They found a strong Tide, setting out of the Streight to the Northward, and like to founder the Ship ; " but whether Flood or Ebb, they knew not ; " only it made a short cocking Sea, as if it had been a Race, where two Floods met, for it
" ran

“ ran *every Way* : Sometimes breaking in over
 “ their *Waste*, sometimes over their *Poop*,
 “ sometimes over the *Bow*, and the Ship *tofs’d*
 “ like an Egg-shell ; so that they never felt
 “ such *uncertain Jerks* in a Ship : And belike
 “ the *Ship* in with the *occurring Floods*, where the
 “ *Passage* was *straitest*.

Secondly, As to the *Bosphorus*, which, tho’ it
 be a *Streight* between two *Inland Seas*, without
 any *Connexion* with the *Ocean*, or *Depen-*
dance on its *Tide* ; yet ’tis obnoxious to as
 great a *Diversity of Currents*, which proceed
 from *different Causes*.

1st, Concerning that *Current*, out of the
Euxine Sea into the *Archipelago*, from *North* to
South, it necessarily *descends* by the *Propension*
 of its own *Weight* (having neither *Wind* nor
Tide to drive it) ; and consequently it de-
scends from a *higher Station*, to a *lower* ; the
Euxine overflowing the *Archipelago*, as being in
Proportion replenish’d and *swell’d* by the *Da-*
nube, *Tanais*, *Boristhenes*, &c. more plentiful-
 ly than the *Mediterranean Sea*, which exceeds
 it at least thrice its *Compass*.

2dly, Whereas the said *Stream* is but *six Foot*
 deep, and floats upon a *contrary one* out of the
Archipelago, which *preponderates* it, as is found
 by sundry *Experiments* ; ’tis no more a *Won-*
der, that it floats upon the *Surface* of the *Ad-*
verse Current, than that *Oil swims* upon the
Surface of other *Liquors*.

3dly, Nor is it more strange, that the *Salter*,
 and consequently the *denser* and *heavier*, *Wa-*
ter of the *Archipelago*, shou’d force its *Way* un-
 der the *Euxine Stream*, into the *Nor.b* by its
 Pre-

Preponderation (which is *fresh* and *lighter*, and so less able to *resist* it): And the nearer it sinks to the *Bottom*, still it becomes more *ponderous*, and enabled to *press forward*, in Proportion to its Weight upon a deeper Descent; especially about the *Middle* of the Channel, where the *Counter-floods* have Liberty to express the Energy of their *Height*, and *Weight*, to the greatest Advantage.

Finally, if it be true, as is reported, that the *Two Coasting Currents* of this Strait, run *counter*; that, on the *West* Side, towards the *South*; while the other on the *East*, returns into the *North*; it is no more than *ordinarily* happens, when the *fresh* and *salt* Floods [being diverted at the *Entrance* into any of our *Ports*, each apart to the *contrary* Side, by some latent *Rock*, or oblique *Bank of Sand*]; the one comes *in*, and the other goes *out* at the same Time; passing by each other *distinguishably*, perhaps for a *League* together: So in our present Case, the *opposite* Mouths of the *Bosphorus*, being diverted *several* ways, direct their *Coasting Currents*, the one towards the *Euxine*, and the other towards the *Archipelago*, after the same Manner.

Thirdly, The *Atlantick* Tide, which sets into the *Mediterranean* Sea, thro' the Strait of *Gibraltar*, swells the Stream which transmits it thither, and lets it fall *alternately* at every *six Hours* End; with an Interval of *twelve Minutes*, like the *Magellanick Gulph*; and both are devolv'd together, down the *Middle* of the Channel; while each precedent Flood returns, by *Result*, from the *Bottom* of the *Levant*;

vant; partly restored by *Libration*, and partly re-enforced by the *Encreasing* Pressure of the *Southing Moon*, to refund on each Side a *Coasting Current* into the *Ocean*, whence it came; as the *Boat-man*, where he cannot stem the *Middle Stream*, follows the *Bank* to find calmer Water.

And, that this *Secondary Resulting Tide*, may reach the Height of the *Primary* one (besides the *Moon's* aforesaid Re-enforcement), the joint *Inclination* of the opposite *Shores*, up to the *Streight's Mouth*, concurs to unite, and proportionably to raise the Height of that Tide, which was before dilated and lower'd all the way, from *Sicily* (the *Axe* of its *Libration*) on each Side of the occurring Stream; so as to refund part of their borrow'd Water, into the *Ocean* itself; 'till the undistinguishable Union of all three Floods in one, sufficeth to re-advance still another resulting Tide, to an equal Height with the former, which immediately preceded it.

Thus the Diurnal Course of the *Moon*, drives the Tidal Tumour with Ups and Downs, of six Hours apiece, from the Bottom of the *Streight's Mouth*, to the Point of *Gibraltar*, East and West; and the Weight of her Pressure being advanced, in Proportion to the Height of her Advance towards the South; the said Tumour must swell most, at the Places that extend farthest North; as at *Venice*, in the Bottom of the *Adriatick*; and at *Marseilles*, in the Gulph of *Lyons*; where it swells a Foot, whereas it bears up elsewhere, scarce six Inches: But her Advance lying between East and West all

all the while, the yielding Tide must be driven towards *N. W.* and result from *N. E.* on the *Spanish Shores*, for Instance ; and run from *C. Frangerola* into the *Streight's Mouth*, at South-west, as is found by the *Pilot's Observation* : And, since he has furnish'd us with a very accurate Account of the several Motions of the Tide found therein, 'twill not be amiss to have their sundry Appearances farther examin'd, and fully discuss'd.

S E C T. VIII.

A more particular Account of the Tide, in the Streight of Gibraltar, from Experience and Reason.

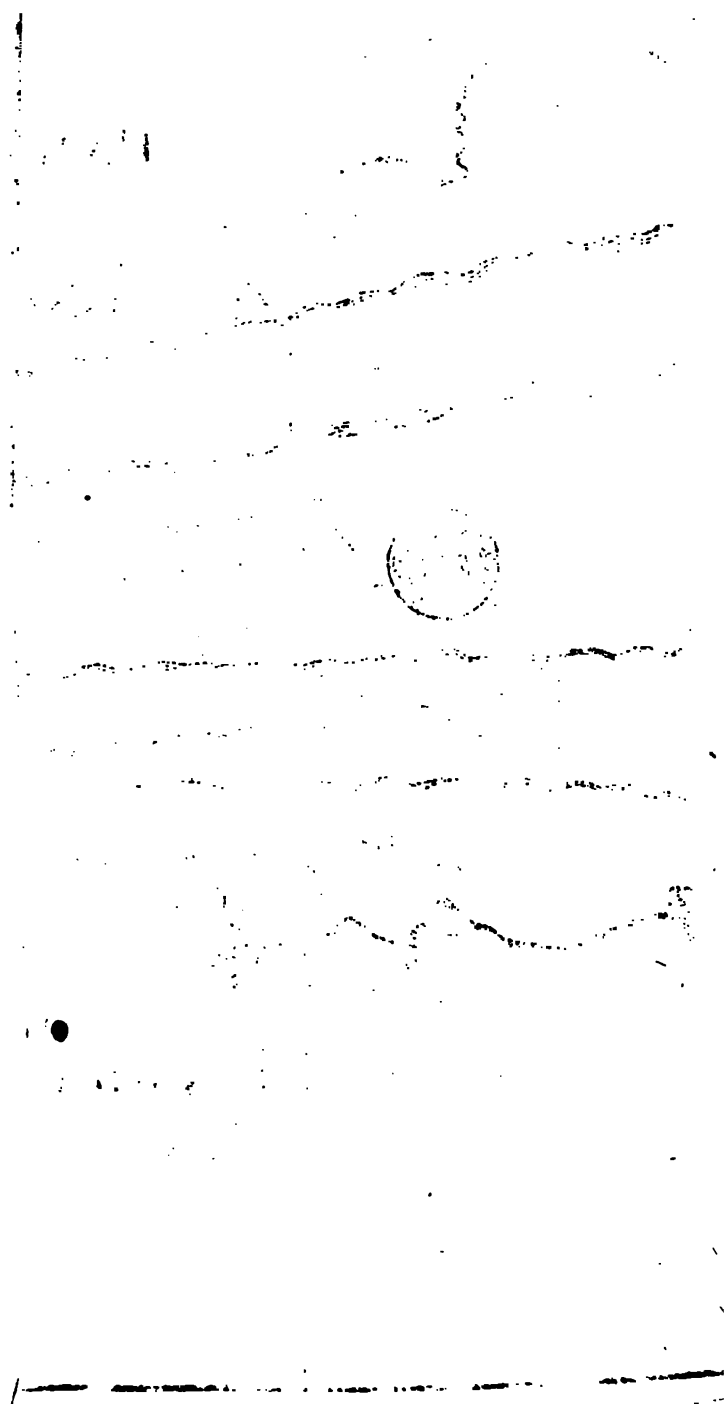
TO give my said Account, an unquestionable Assurance ; 1st, I produce for it, as to Matter of Fact, our *English Pilot's* Observation, in his own express Words : 2^{dly}, In regard the *Streight's Mouth* contains Five sundry Streams, which pass thro' it out of the *Atlantick Ocean*, into the *Mediterranean Sea* ; I delineate 'em to the Eye in a Map, exactly the same with his : And, 3^{dly}, Forasmuch as their Currents differ no less in Point of Time ; I extract their Periods also, out of his *Tide-Table* : only abridge, as to the Diurnal Course of the *New-Moon Tide* ; and begin, as he doth, with the Description of that, which is peculiar to *C. Tariffe* and *Tangier* ; and the only one, that flows out of the East.

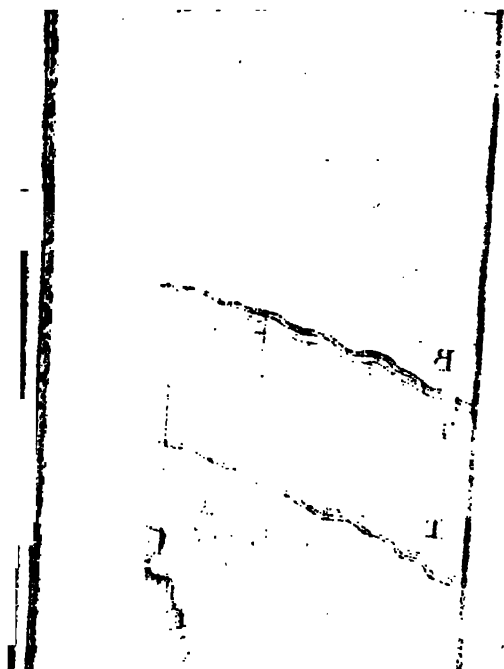
The

The Pilot's Observation, of the Tide in the Streight of Gibraltar, is as follows, viz.

“ At *Tangier* and *Tariffe*, a *S. W.* by *S.*
 “ Moon maketh full Sea, at $II \frac{1}{4}$, on the *Shore* ;
 “ but in all Parts of the *Streight's Mouth*, the
 “ Flood runs until a *W.* by *S.* Moon, or $V \frac{1}{4}$:
 “ All the other Parts of the *Streight's Mouth*,
 “ have Flood out of the *West*, which runs in
 “ from *C. Spartel*, and *C. Trafalgar*, on each
 “ Side, along by the *Shore*, much stronger
 “ than in the *Middle* ; to the *Eastward*, as far
 “ as *C. Cabrita* on the *Spanish Side*, and *Ape's-*
 “ *Hill* on the *Barbary Side* ; and at these Two
 “ Points, meets the Flood that cometh out
 “ of the *N. E.* about the *Point of Gibraltar*,
 “ and runs *S. W.* into the *Streight's Mouth*, all
 “ the first quarter Flood ; and the Remain-
 “ der of the Tide, the Flood setteth from the
 “ *Point of Gibraltar*, *W. S. W.* towards *C. Ca-*
 “ *brita*.

“ At the *Top* of High-water, there cometh
 “ always out of the *West*, between the two
 “ *Capes*, a Race of a Current, which spread-
 “ eth the *whole Streight's Mouth*, from Side
 “ to Side, but continues on neither seldom
 “ longer than *half an Hour* ; but in the *Middle*
 “ of the *Streight's Mouth*, the Current runs to
 “ the *Eastward* very strong, all the Tide of
 “ Ebb ; and the Race of a Current, falleth
 “ always between *Ape's-Hill*, and *C. Cabrita*,
 “ at a *W.* by *S.* Moon ; and at that Instant be-
 “ gins the Ebb, on the *West Side* of those two
 “ Points, to run to the *Eastward*.





The Tide of Ebb, on the *Spanish Coast*, runs from *Cape Cabrita*, about two Leagues broad from the Shore, as far as the *Land of Tariffe*; and runs between the Land and the Main, all the Tide of Ebb, long by the Shore, towards *Cape Trafalgar*; but on the *South Side* of the Island, the Ebb runs very narrow, except it be in a Set fair Weather.

The Tide of Ebb, on the *Barbary Side*, runs from *Ape's Hill* but narrow along the Shore, as far as the *Point of Alcasar*; but, on the *West Side* of the Point, thwart of the Bay, the Tide runs about three Miles broad; and at the *C. Malabata*, which is the Easternmost Point of the *Bay of Tangier*, about two Miles broad; and so continues to the Westward, out to *C. Spartel*; and from hence, the Ebb runs *S. W.* along the Shore, towards *Salley*.

The Ebb, to the Eastward of *C. Cabrita*, and *Ape's Hill*, is begun by the foresaid Race of Current, which spreadeth from the one Side to the other, between *Gibraltar* and *Ceuta Point*, and runs in *E. N. E.* in the Middle; from the Point of *Ape's Hill* to the Point of *Ceuta*, along the Shore, all the first half Tide; and the remaining half Tide, the Current runs from *C. Cabrita*, *E. S. E.* into the *Streight's Mouth*, by the Point of *Ceuta*; and from the Point of *Gibraltar*, the first half Ebb runs *N. E.* into them, towards *C. Frangerola*.
Thus far the *Pilot's Observation*.

The *Pilot's* Delineation of the *Strait's* Mouth, with regard to its five-fold Trade Currents, is as I have described in the foregoing Map: Now, to inspect his Table of the Tides for the *Periods* of their Floods and Ebbs, upon every Line; *First*, From the Line B, to the *African Shore*, the Tide begins to Flow *Eastward*, at 10^h; and Ebbs to the *Westward*, at 4^h: And from the Line C, on the *Spanish Coast*, it begins to Flow to the *Westward*, at 11^h; and to Ebb also to the *Westward*, at 1^h; yet, between the Offing Lines TT on the one Side, it Flows not to the *Eastward*, till 1^h; and Ebbs not to the *Westward*, till 8^h: And between the Offing Lines OO on the other Side, it begins not to Flow to the *Eastward*, till 2^h; nor Ebbs to the *Westward*, till 8^h; while the *Middle Current* still Flows to the *Eastward*, at near the same Height, without Intermiffion.

Seeing therefore all these Floods and Ebbs are stirr'd up, and let fall again, by the same Flux and Reflux of *one single Wave*, or Tumour of the Sea, yet no Two of either Sort begin to rise or subside at the *same Time*; the Question is, how they become so differently dispos'd, to resent its Impulse?

First, The *Coasting Streams*, which first receive its Influence, are best dispos'd for that purpose; as having no special *Inclination* of their own, to resist it; nor *Depth* of Water, for any to be impress'd into; but, Floating upon shallow and *shoaly Bottoms*, are easily stirr'd, and as soon appeas'd, like *shallow Lakes*, upon every Wind that blows, or Calm that

It happen; and so must take the *first* No-
of any Commotion.

On the contrary, the *Middle Current*, ha-
g *Fall* enough to direct its Flux to the *East-*
ed, and Channel of *ten Leagues* to continue
ne same; having also *Depth* of Water to
l forward, and the *Atlantick Ocean*, to
p it supply'd to its full Height: Without
ediment of Coast, or Shore, to *deflect* its
arise, or *lessen* its Speed, must suffer no De-
edence on the *Moon*, to hinder its Precipi-
on.

ut the *Offing Floods*, interposing between
two Extreame, must *partake* of both these
reams, by their mutual Coherence; the
astancy of the one, so as to Ebb and Flow
Lunar Influence; and withal the *Steady-*
of the other, not to be wrought upon
r-hastily; but, as it is *three Hours* later, in
iving the Tidal Impression; so to pre-
e it as much *longer*; but yet as all these
erent Motions being regulated, by the
e's *six hourly* Revolution; so at every six
rs End, to make, by a timely Ebb, Re-
tion. And,

first, The *Pilot* observes, that the *Coasting*
nm, on the *Spanish Side*, that begins to
v at 11^h, and shou'd continue so 'till 5^h,
es High-water at *Tariffe* an Hour and half
er: *2dly*, That the *Coasting Tide*, near
African Shore, which begins to Flow at 10^h,
shou'd Ebb at 4^h, continues running 'till
3dly, That the *Offing Floods*, which be-
not to swell 'till 1^h and 2^h, and shou'd
v 'till 7^h and 8^h; yet fall with the gene-
Ebb, between *C. Cabrita* and *Ape's Hill*,

at 5^h: *Lastly*, That the Tide from the N. E. both Flows and Ebbs to the *Westward*, out of the *Mediterranean* into the *Atlantick*, whose Situation must be *higher*, to give the *Middle Current* the quite contrary Motion: Now, to reconcile the *Pilot's Calendar*, to his *Observation*; and both to Truth, in the Points aforesaid;

Concerning the *First Point*; to wit, That the Tide which came from the N. E. and began to Flow at 11^h, and boldly enter'd the *Streight's Mouth* to S. W. at the dead Ebb, for the first Quarter of its Flood; ('till the Remainder was deflected from the *Point of Gibraltar*, to W. S. W. by the Springing *Western Tide*, towards C. *Cabrita*, and thence to Cape *Tariffe*); made High-water there, at 2^h $\frac{1}{2}$; that is, two Hours and an half before 5^h: When, according to the *Pilot's Tide-Table*, it shou'd have begun its Ebb: *Answer*. But the Sea was Full at half Tide there, in regard the *Coasting Channel* was straitest; and withal an *Island* was objected to its Course, when its Flux was briskest, and had Water enough to result, at its first Appulse, *higher* than the Stream was able to maintain, after the Energy of that Push was over; tho' it continued to Flow afterwards, to its full Time.

The same Tidal Tumour that came from the N. E. makes also Full Sea at *Tangier*, on the opposite Coast of *Barbary*, near the same Time; having pass'd from *Ceuta Point*, by *Ape's Hill* and C. *Alcasar*, as far as C. *Malabata*; where the Coast most straitens, and Rocks oppose it; and withal, the *Western Flood* occurs,

curs, to swell it as high at *Tangier*, as it rose before at *Isle Tariffe*; yet with this difference, that the Tide of Ebb continued its Course to the *Westward*, beyond *C. Trafalgar*; whereas this *Eastern Flood* is born to the *Eastward* whence it came, by the *Current* out of the *West*; before it reach *C. Spartel* towards the *Ocean*, to compleat its six Hours Ebb.

Secondly, It is observ'd, that the *Coasting Tide*, on the *African Side*, which begins to Flow at 10^h; and has but 'till 4^h, allow'd it to its Ebb by the *Tide-Table*, yet continues running to the *Eastward*, 'till 5^h at least: *Ans.* That the *First* of the Tide, is carried to the *Eastward* so far, by the *common Current* out of the *West*; while the *binder End* of its Flood is upon an Ebb, after the said Allowance is expired: As Sea-floods in *fresh Rivers*, Ebb near the Sea, while they Flow to the *Landward*, at a greater Distance.

Thirdly, That the *Offing Floods*, which begin not to swell 'till 1^h and 2^h, in the *Afternoon*; and ought to Flow 'till 7^h and 8^h, at *Night*; yet Fall, between *C. Cabrita* and *Ape's Hill*, at 5^h in the *Evening*; with the general Ebb of the *Western Flood*, in all Parts of the *Streight's Mouth*, at once: *Ans.* Notwithstanding, they continue their Flux to the *Eastward*, to their stated Terms of *six Hours* apiece, though they cannot re-advance the Tide to that *topping Height*, it had before; and they return not their Stream of Ebb, 'till it be withdrawn by the *Tidal Reflux* of the *Ocean*; which set it on foot *so late*, and was as long in *withdrawing* it Motion; which was done with equal Difficulty both ways,

and consequently must be perform'd in the same Space of Time.

Fourthly, That the aforefaid N. E. Tide, both Flows and Ebbs, along the *Spanish Shore*, perpetually to the *Westward*, quite contrary to the *Middle Current*, which runs without any Tidal Ups and Downs, as constantly to the *Eastward*; and consequently from the Higher Situation of the *Atlantick*, into the Lower of the *Mediterranean Sea*; which seems to render the contrary Motion of the Tide impossible: *Ans^w*. To make those opposite Flux's consistent, it sufficeth that the *Mediterranean Flood* advance above the *Atlantick Ebb*, to convert their Courses: Nor does the Flux of the *Middle Current* intermit, at Low-water, nor exceed when it is highest in the *Atlantick*, but observes the *Mean* betwixt 'em: As the Spout of a Pump keeps to a constant Stream, tho' the Water in the Tube rise and fall at every Stroak, ten or twelve Inches; yet the Side Streams, sometimes exceed the Speed of the *Middle Current*, between C. *Cabrira* and the *Congress-height*: Hence it is observ'd,

Fifthly, That the Tidal Flood out of the *West*, runs more strongly from betwixt C. *Trafalgar* and C. *Spartel*, than the *Middle Current*; which observes a *Mean* between the highest Flood, and the lowest Ebb; and follows the Shores of *Spain* and *Barbary*, till it meets the N. E. Flood, between C. *Cabrira* and *Ap's Hill*, where they Counter-swell each other, till the Water be full thro'out the *Strait's Mouth* (*Tariffe* and *Tangier* excepted) till 5^h; that the *Atlantick Flood*, which made High-water on the Promontories of *Ireland*, *France* and *Spain*,

Spain, at 3^h; and fill'd their *Ports*, at 4^h; now reacheth the Bottom of the *Streigh's Mouth*, and fills all full, at 5^h; and bears down the *Eastern Ebbing*, which damm'd up their Passage thitherwards, all the while: 'Till,

Lastly, As this Universal Deluge came from *all Parts*, and chiefly from *E.* or *W.* with a Point or two of *N.* or *S.* so, after the Top of the Tide, has broken down the Rampire of the Tumour, that withstood it; a general Push is made to the *Eastward*; yet, after *half an Hour* is over, it Ebbs every way at once, from the Topping Height: The *Middle* flows *Eastward*; the *North Stream*, towards *Gibraltar*; and the *South*, to *Ceuta Point* with Freedom, without any *Deflection* for the first Half-Tide of Ebb: But the *Remainder* is driven by the *N. E.* springing Flood, by degrees transversly, *thwart the Mouth* of the Streight, from *C. Cabrta* to *Ceuta Point*; to end this Tide, with the *beginning* of the next, and perfect the Circle.

The *Pilot*, having finish'd his most accurate *Observation*, gives us a Cast of his *Office*; by directing, how to turn thro' the *Streigh's Mouth*, the Wind being *Westerly*: viz. To ply to the Windward on the *Spanish Side*, from the Point of *Gibraltar* to *C. Cabrta*, and from thence to *Isle Tariffe*: And, having *Tided* two or three short Boards up to the Windward, a little before High-water, and the Race of Current out of the *West*, the Ship is to be *Anchor'd* there, 'till so much of the Tide be spent, as to get over to the *Barbary Side*; and take the Tide of Ebb, as to fall to the *Westward* of the Point of *Alcasar*, that she may get

into the *Bay of Tangier*, by a Low-water; and observing the Tide, may turn at Pleasure.

So easily are resolv'd the *Doubts* and *Difficulties*, arising from the *various Tides and Currents* of those Friths and Streights, that interfere between Seas of all Sorts; particularly the *Magellanick*, the *Bosphorus*, and that of *Gibraltar*; which, for the *Multiplicity* and *Contrariety* of their Fluxes, seem to include and explicate all the rest: Only certain *Mistakes* remain to be rectified, concerning the *Causes of Whirlpools*, found in some Seas; and of *subterraneous Rivers*, fancied to be in others; and both upon *weak* Grounds, and for *impracticable* Uses, as shall be demonstrated in the ensuing *Section*.

S E C T. IX.

Of Whirlpools, stirr'd up in the Sea; their Dependance on the Tide; and, how they are occasion'd.

SINCE the whole Course of the Tide is *progressive*, and *direct*; as far as the Obliviousness of transverse *Coasts* and *Shores* permits: It occurs to enquire, How such a *circular Whirling* of Water can be stirr'd up, even in the *Ocean* itself, by its Means; and for what *Use* it may serve? And to direct our Enquiry, 'twill not be amiss to consult those *Eddies* in *Brooks*, and *Rivers*, which much resemble
'em

'em nearer home ; and examine, *how* they are made to the Bottom ; which may be done as good cheap, and with less Labour.

First, To stir up such *Whirlpools*, as every small Rill is capable of ; it is requisite, that the Current which produceth it, be, in part, deflected by some Bank of Sand, Gravel, &c. into a shelter'd adjoining Pool of calmer Water ; where it has Liberty to wheel about its crooked Confinement, 'till it rejoin its own Stream, where it began to circulate : But falling within its former Compass, its Revolutions still become more and more contracted, spirally, and they terminate at last, *Periwinckle-like*, in the Center of their Circumgyration ; whither it carries all its Wreck of Straw, Leaves, &c. to turn around their own Center, without End or Limit ; and the like happens in Rivers, and Arms of the Sea, where the fresh or salt Floods meet with Shores, or Shelves, which are apt to turn and wind 'em into Gulphs, and Whirlpools, of a larger Extent.

Secondly, It is to be noted, that Sands and Shelves under Water, as effectually cause the aforesaid Deflection, &c. as the Banks and Shores do above it ; and, by the Crookedness of their Channels, inflect the Sea-Currents into spiral Circumvolutions ; so that the incumbent Surface of the Sea-water, wheels about, and is revolv'd circularly whence it came, in compliance with the Streams underneath, by their mutual Cohesion, as aforesaid : Thus the Effect is patent, tho' the Cause be concealed ; as well in the Ocean itself, as in our Rivers, or Arms of the Sea, according to the several

Of Whirlpools,

several Situations of the *Bottoms* they move upon.

Thirdly, It is observable, that, while the Brook, or River wherein they are found, continues *rising*, the *Whirlpool* flows higher about its *Circumference*, than at its *Center*; and when it *falls*, on the contrary: As other Streams are *higher*, at the Place whence they actually flow, than whither they finally tend: Hence it is, that *Flowing*, they gather the Wreck to their *Centers*; and when they *fall*, disperse it: So the *Whirlpool*, for the same reason, while the Tide flows, *attracts* those Ships into its Center, which fall within the Compass of its *Spires*; by letting 'em descend all the while, 'till they be *overset* and swallow'd up; which, upon its Ebb is *cast up* again, and scatters their Wrecks around over the Sea, by a *contrary* Revolution.

Fourthly, To make this Appearance more remarkable, it is to be noted, 1st, That *Flowing* Streams are of a *Convex Superficies*, so as to be protuberant in the Middle; and *Falling*, they become *Concave*: Hence it is, that the Flowing Tide, makes the Surface of the Ocean to appear *rais'd*; and the Ebbing, to be as much *depress'd*; which makes the *Whirlpool* seem to *sink* into the Sea, at the one Season, and to *rise* out of it again at the other: 2^{dly}, Since flowing Streams cannot *stop* on a suddain, the *Whirlpool* riseth longer, than the Impulse of the Current drives it: 3^{dly}, The Channel which conveys it, being wider at its *Entrance*, than after 'tis *spirally contracted*; it must needs raise its Center much higher, than the *Circumference*.

Two such *Gulphs*, as I have described, lie too near us to question their Existence; the one, in our *South Channel*, near *Normandy*; and the other is that famous one in the *Ocean*, upon the Coast of *Norway*; both which draw Vessels *spirally* into their Cavities, by the Help of the *Flowing Tide*; and when it *Ebbs*, return 'em back again from their Protuberances, either *broken* or *whole*, by the same vertiginous Tracts; That, upon the Coast of *Normandy*, restores 'em to their former Liberty, *safe* and *sound*; by gently unfolding those *Spires*, which invol'd 'em before: But that other near *Norway*, dashes 'em to pieces upon the *Rock*, in the Middle of it, and scatters their Wreck all the Sea over; without *swallowing* 'em down in *Gulphs*, or *Rivers under-ground*; or casting 'em up again, as is commonly apprehended.

Hence plainly appears, that no Consequence can be drawn, from the alternate *Rising* and *Falling* of those *Gulphs*, that they hold a Correspondence with others of the same Nature, *under-ground*; which *supplies* 'em with Water, when they want it; and *takes it off* again when they abound, by *subterraneous* Cavities made for that purpose: But, as a *Spout*, falling obliquely into a *Tunnel*, contracts alike a *Whirling* about its Brink, whether the Pipe underneath be *stop'd*, or *open*; so do these *Gulphs*, without any such *subterraneous* Communication, put on as *diverse* Appearances, by *swelling* or *sinking* alternately, in all Places; and *rejecting* vicissitudinarily, what they had *attracted* before.

S E C T. X.

A more particular Account of the Vortex, or Whirlpool on the Coast of Norway ; and, how it is caused in every respect.

TO exemplify what I have said already, of the Nature and Production of Whirlpools in general, by the Recital and a farther Discussion of *this*, on the Coast of Norway : In order to infer, that *subterraneous Aqueducts*, are no more required to produce 'em in the *Ocean* itself, than in *Brooks*, and *Rivers*, where no such Supplies can be pretended ; to deal impartially between them, (since the Disparity must lie, in the Disproportion of the *Cause*, to the *Effect*) : First, I produce, in behalf of the *Effect*, the *Description* given of it, in the *Grammar of Geography* ; which asserts ; that, in all Probability, the said Whirlpool is occasion'd, by some mighty *subterraneous Hiatus* : And, on the contrary, to give the *Cause* its due Force, and Application, I expose it to the View of *Sense*, as well as *Understanding* ; and exhibit the Place *Where*, and *How* that Pool is seated, according to Mr. Moll's *Map of Europe* ; only *enlarged*, to shew what Advantage the Tide makes of the *Situation* thereof, to give the Water its *Whirling Motion* ; agreeable to the Account already given of it, in the precedent *Section* : Take here, the said

DESCRIPTION, *Viz.*

“ Upon the Coast of NORWAY, near the
 “ *Isle Hitteren*, in the Latitude of 68, is that
 “ remarkable and dangerous *Whirlpool*, com-
 “ monly call’d MAOLSTROOM, and by Naviga-
 “ tors the NAVEI of the *Sea* ; which *Whirl-*
 “ *pool* is, in all Probability, occasion’d by
 “ some mighty *subterraneous* HIATUS, and proves
 “ fatal to *Ships* that approach too nigh, pro-
 “ vided it be in the Time of *Flood* ; for then
 “ the *Sea*, upwards of *two Leagues* round,
 “ makes such a terrible VORTEX, that the Force
 “ and Indraught of the Water, together with
 “ the Noise and Tumbling of the Waves upon
 “ one another, is rather to be admired than
 “ express’d: But, as in the Time of *Flood*,
 “ the Water is *drawn in* with a mighty Force ;
 “ so, during the Tide of *Ebb*, does it *throw*
 “ out the *Sea* with such a Violence, that the
 “ heaviest Bodies, then cast into it, can’t
 “ sink ; but are *tos’d back again* by the impe-
 “ tuous Stream, which rusheth out with in-
 “ credible Force : And during that Time, is
 “ abundance of Fishes caught by *Fisher-men*,
 “ who watch the Opportunity ; for, being
 “ forc’d up to the Surface of the Water, they
 “ cannot well dive again, so violent is the
 “ rising Current.

Seeing therefore the foregoing *Description*,
 is so far agreed with my former Account, that
 Currents are the effective Cause of *Whirlpools*,
 wheresoever they happen ; as to acknow-
 ledge, that, in the Time of *Flood*, is made
 that

that terrible *Vortex*, that proves so fatal to Ships on the Coast of *Norway*: And that during the Tide of *Ebb*, the Water is thrown out with Violence, that was drawn in before; and that is said to be the *Cause*, which being put, or taken away, the *Effect* correspondently followeth, or ceaseth: The Tide stands fair to be the *Cause* of the *whirling Motion*, as well on that Coast in the *Sea*, as the Currents in *Brooks* and *Rivers*, do of their *Eddies* and *Whirlpools*, of a smaller Size.

And if it be doubted, lest the said *Cause* shou'd want sufficient *Power*, or *Application*, to produce so prodigious an *Effect*; as that, in all Probability, some mighty *subterraneous Hiatus* were required, to help it out; the Situation of the *Place*, is to be farther consider'd; and the foregoing *Map* to be inspected, to find where the Disadvantage lies: Which (if any were to be found,) wou'd be exhibited to Satisfaction.

First, As to the *Application* of the Tidal Force, on the Coast of *Norway*, where this *Whirlpool* rageth; since it setteth right upon all open Shores, from the *Middle* of the Ocean; and these of *Norway*, are extended from S. to N. and lie open to the *West*; the *Western Flood* must fall upon this Pool, at the best Advantage; as lying situated between the utmost Points of the *Ile Rust* and *Losfoet*, which bear N. and S. to each other: And, in regard the *West* Coast of the former *Island*, lies extended from Cape (a) to Point (b) from S. W. to N. E. for four Leagues together; the Declivity thereof, contracting

tracting the Stream all that way, to a *third Part*, before it touch the said Pool; it must be stronger and swifter, as *three to one*; to enforce that *whirling Motion* upon it more powerfully, than the common Stream of the Ocean, whence it came; and withal, its Current continuing *five Miles in Breadth*, must supply it with Water more abundantly.

2dly, As to the Point of *Incidence* upon the said Pool at (i), the Stream drives its Motion, on that Side, opportunely thence, from S. to N. as far as (c); where *this Tidal Current*, from (a) to (c), meets with *that* of (A. B. and C.), from the Back-side of the said *Isle Ruff*; which, with an *oblique Stroak*, diverts it to full *North*: And both their Streams, being *conjoin'd*, are *straiten'd*, and *swell'd up*, on all Sides *at once* from the *Eastward*, by the *Islands* (o. p. and q.); and from the *Northward*, partly by the *Stream* (k. l. and m.); and partly, by the *S. East Coast of Losfoet-Isle*; from Point (h) to (f), and their joint Stream is forced thorow the Passage *between* (d.) and (f), to the *S. West*, as far as (e), into lower and *calmer Water*; the Tidal Stream out of the *West*, being in part carried off by Point (f), into the *Bay* between (f. and g), while their Stream is *drawn* by the other Part of it towards (i. and (b), where the *Circulation* first began, and is now perfected.

3dly, This *first Circumvolution* of the Tidal Stream, about the Brink of the *Whirlpool*, being finish'd; the Flood brings on a *Second circular Wave*, which, by degrees, *surrounds* the former; till a *Third*, supervening, *involves* *em both* within its Compass; into which a
Fourth,

Fourth, contracts *all Three* ; as the rest do *successively* one another, 'till the inmost penetrates the *Center* of their Circumgyration, and puts a *Stop* to that which follows it ; and each to other, as so many *Rocks*, to break the pursuing Waves ; 'till the *last*, which flows highest, tumbles over *all* the rest, from upwards of *two Leagues* in *Compass* ; with *Noise* and Disorder, beyond all Conceit and *Expression* ; the *Navel-Tumour*, towards which they *tend* all the while, swelling to a Height extraordinary, during the Time of the *Flood* ; which still repeats its Impulse, and furnisheth Fresh-water perpetually, 'till its Flux be over.

Atbly, The Flood being *spent*, and its Impulse lost, the Tide of *Ebb*, first *withdraws* the *utmost* encircling Wave ; which lets the *next* Fall after it into the Deep ; and the *Third*, after 'em both ; and the *Fourth*, after all ; and the rest *successively*, tumble one over another ; 'till the *Central Tumour* (which swells all the while), be let fall over *all those* accumulated Ridges of Water, which supported it, from the Summit of its *Height* around, to the *Bottom* of the *Ebb*, with an irresistible Precipitation : So as to *push away* whatsoever is thrown into it, that the *heaviest* Bodies can scarce sink ; and the *Fins* of Fishes, can no more serve 'em here, to escape the *Fishers* Nets ; than *Rudders* can steer *Ships* out of this *Whirlpool*, and save 'em from staving in Pieces : So useless and improbable, are *subterraneous Hiatus's*, found under the Sea, in *this Section* ; and as vain and impossible, in the *next*.



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S E C T. XI.

Of Indraughts of *Water*, and Subterraneous Rivers; and their Accommodation to Land and Sea.

THE Gulphs, and Whirlpools, mention'd in the precedent Section, are so commonly conceiv'd to be Indraughts of Water, holding an alternate Communication with Rivers, and Caverns fill'd with such Matter, under-ground; that, to go about (as I have done) to disprove it, seems to be a flat Denial, that any such *subterraneous Passages* and *Receptacles*, are probable: I shall, instead of that, labour for an Accommodation, by Replying to what is usually urg'd in behalf of their Existence.

First, When it is objected, that such Indraughts of Water, as the aforesaid Gulphs are imagin'd to be, are required to keep *Inland Seas* within their Bounds, and to prevent *Lakes* from overflowing; and the *Caspian* is instanced for such; which, notwithstanding the Confluence of several vast Rivers into it, of which the *Volga* is one of the first Magnitude; yet swells not with its Floods; nor, in the least, resents the inequality of Rain in *Winter*, above the Drought of *Summer*:

It is reply'd, that, in regard all those Rivers drain no more Ground by their Floods, than the *Caspian* watereth with its Vapours; it cannot spare any Surplusage of Water, to overflow its Shores; nor needs that Sea to swell in

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Winter,

Winter, while the *Volga* is frozen up in the North; and the *Snows* are not thaw'd about *Novogorod*, 'till *Mid-April*; and are not dis-embogu'd, at *Astracan*, into the *Caspian*, until *Midsummer*; tho' the rest of the Rivers most abound with Water, for all that Season: Nor is it to fall in *Summer*, upon so vast a Recruit, when those Rivers are almost dry'd up, by the scorching Beams of the Sun: So that no such *Gulphs* are required, to keep it up to the same Height, at either Season.

When it is alledg'd, that *Guadiana* finds a subterraneous Passage, seven Leagues long, to prevent its Inundation of a considerable Part of *Spain*; and the *Caspian* must do the like, to pass off the Streams aforesaid, perhaps into the *Euxine*, that *Persia*, &c. may escape the said Misfortune:

It is again reply'd, that the Parity doth not hold, to make good the Consequence: For, altho' such Passages be as possible, in both Cases, as it is for Bridges to be made, either by Art or Nature; and for Rivers to pass under'em, upon a competent Descent; and such an one is necessary, in the former Case; yet it does not appear to be either useful, or practicable in the latter: For First, the *Caspian*, being of equal Extent with our *Great-Britain*, and lying as far South as *France*; to expand those Streams, and expose 'em to the scorching Beams of the Sun; seems sufficient to resolve 'em into Vapours, and prevent its Overflowing: Nor is it probable, that the *Euxine Sea* lies lower than the *Caspian*; since the said Rivers run a longer Course, and require a greater Descent, than any in *Europe*: Besides, *Spain* has
less

less need of such a *Lake*; being, on *three Sides*, surrounded by the Sea; than the *Nations* bordering upon the *Caspian*, at *seven hundred Leagues* distance from it: But wonderful is the *Divine Providence*, and faithful to his Promise; to water a considerable Part of *Africk* with the Flood of *Nile*, like a Garden; and a no less Compass of *Asia*, by the Vapours extracted from the *Caspian Lake*, with the Dew of Heaven.

And whereas is urg'd the Necessity of such *subterraneous Currents*, out of some Seas into others, which wou'd otherwise prove superfluous, and unaccountable: *Ans^w*. As is mistakingly conceiv'd of the *Coasting Stream*, on the South Side of the *Mediterranean*, which follows the *Barbarian Shore*, from *Gibraltar*, Eastward, as far as *Aleppo*, without any Return: And of the Current on the West of the *Adriatick*, which runs perpetually Southward, along the *Calabrian Coast*, as far as it reaches: For these (as I have already shewn) are only Currents, that make *Restitution* for the Tidal Tumours, that follow the opposite Channels, which circulate into each other: But what is worth the Remark is, that the *subterraneous Conveyances* of Water, which are suppos'd to pass out of these Seas into any other, are absolutely impossible; the *Adriatick*, lying on the same Level with the *Mediterranean*, which lies lower than the *Ocean* itself, that flows into it without Intermiſſion.

Yet upon such Surmises as these, some Authors fancied the Earth to be an *Animal*, which ejected the Tide, and swallow'd it down again by *Respiration*, thro' bottomless *Gulphs*,

and *Indraughts* of Water, reported to be found in *some Seas*; yet so rarely, and with so *little Effect*, even upon the adjacent Shores, that they cou'd no more be thought to influence the *common Course* of the Tide, around the Universe; than that the Flame of a *Candle* might suffice to illuminate a whole Nation: But, perhaps those Authors only pretended to *fancy* so, for an Essay of *Wit*, to try whether this Opinion (as *absurd* as it appears) was not as defensible, as any of the rest that were started, about the Cause of the Tide; to turn all their Search after it into a *Jest*.

No less vain and groundless are the Imaginations of those, who still frame to themselves such impracticable Existences, as *subterraneous Rivers*, &c. without any just Occasion; or even a Possibility to be made other Use of, than to discourage their Followers, from searching into the *true Causes*, of the Substance of the Tide; or any such Appearances of it, as these odd Fancies are pretended for; and to drive 'em into an utter *Despair* of ever arriving to any solid Satisfaction, in any such Matters: And in the mean time, they serve their *Authors* themselves, as often as they chance to fall upon any *Difficulty*, which they cannot tolerably explicate, for Subterfuges to conceal their *Ignorance*, and Starting-holes to make their Escape.

S E C T. XII.

A Recital and Explication of such Instances of the various Motions of the Tide, which seem to be the most unaccountable.

TO begin (for Method's sake) with those Tides, which immediately affect the Ocean it self; where the Influence of the Moon's Pressure finds the least Restraint from any Interruption by *opposite Coasts and Shores*; and thence proceed briefly in order to the rest, as behoves a Rehearſal:

The *First* Instance, which is suggested to frame this Order, is, that at *Cayen* under the Equator, the Spring-Flood makes not High-Water 'till the *fourth* Hour after the Moon's *Southing*; nor 'till the *sixth*, after she has pass'd the Great Meridian; and consequently, she had made an *Ebb* at their Interſection, by the Pressure of her Presence, just when it was Flood upon the *same Meridian*, within the *Temperate Zone*: *Expl.* Which is quite contrary to the common Opinon; (*viz.* That it is Flood and Ebb in *both Places at once*) but exactly agrees with Matter of Fact, and the foregoing Doctrine.

Secondly, It is no less wonder'd at, that the Flood upon that *Island*, shou'd ordinarily rise no higher than *six Foot*; and the Spring-Tides never exceed the rest, above *six Inches*; especially lying so near the Congress of the *Ethiopic*, and *Atlantick* Floods, upon the Equator: *Expl.* But it is less strange, in regard

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they arrive not *thither* at the *same Hour* ; so that that which comes *first*, carries off the Stream of the *later*, before it can mount to the Height, which is ordinary in other Places.

Thirdly, The *Ethiopic* Flood is described to come with much more Violence out of the *South*, towards the *Line*, than the *Atlantic* does from the *North*: *Expl.* And there is good Reason for it ; seeing the *former* is dilated from the *Cape of Good Hope*, to the *Magellanick Streight* ; and becomes still more contracted, by the inclining Shores of *Brazil* and *Congo*, to enforce it all the while ; whereas the *later* spreads itself to a greater Breadth, along its Passage from our *British* Coasts, 'till it reach the *Equator*, and becomes weaken'd as much, by its Expansion.

Fourthly, 'Tis observ'd, that it advanceth not to the same Pitch, at the *Tropicks*, that it doth upon the *Equator*, on the *one Side* ; or in the *temperate Zone*, on the *other*: *Expl.* Because the *Tropicks* are the *Axes* of the Tide's *Libration* ; and so it must rise and fall to its full Extent, at each End of its Reciprocation ; while the *Center*, whereon it moves, remains fix'd and steady.

Fifthly, 'Tis observ'd, that 'tis High-water at once, on both the *East* and *West Sides* of the *Atlantic*, in the same Latitude ; as on the Coasts of *New-England* in *America*, and of *Poitou* in *France* ; after three Hours Ebb in the Middle, and so long Absence of the Moon from the Great *Meridian*: *Expl.* Because the Tide had departed each Way, from it, towards the *East* and *West*, to the like Distance,
in

in equal Spaces of Time ; or else the parted Floods had been as different, both for Height and Time ; as the Tides at the *Canaries* are (which lie *nearer* to that Meridian) both stronger, and come sooner thither, than those at the *Caribees*, on the other Side of the *Atlantick* ; because they lie farther distant from its Center, which is their common Source.

Sixthly, Mariners find, more to the *Northward*, a strong Flood at *Hudson's Bay*, and a very weak one on the Coast of *Norway* : *Expl.* Inasmuch as the *former* opens its wide Mouth *immediately* to the Great Meridian, its common Tract ; whereas the *later* declines it no less to the *Eastward* ; and lies more remote, to the *Northward*, from the Course of the Moon, which shou'd enliven it.

Concerning the *different* Influence of her Pressure upon our *narrow Seas*, and *Lakes* ; some have no Tide at all, as the *Caspian* and *Euxine* Sea ; for want of Communication with the *Ocean* ; besides, they have neither Extent, Figure, nor Situation, proper for that Purpose ; whereas some *Lakes*, which are wholly sequester'd from all Commerce with the *Sea* (are reported to be in the *North America*, of which *Two*) having Extent and Situation proper for it, Flow and Ebb, periodically, by the Moon's sole Influence, twice in twenty-four Hours ; tho' they sometimes intermit, or else reach not their usual Height, as is aforesaid.

And as for the *Baltick* and *Mediterranean* Seas, which lie open to it ; the Tide of the

Ocean, being almost spent in the *German Sea*, before it reacheth the *Sounding*; the former, as lying too far *North*, to be influenced by the *Moon's Pressure*, looseth the *Tidal Effect*: And the *later*, which lies at a more convenient *Distance*, partaking it with *Accommodation*; it most abounds where it has most *Liberty* to rowl towards the *North*; as at *Marseilles*, in the *Adriatick Gulph*, and the *Levant*.

Nor is it more strange, that the same *Flood* shou'd rise fifty Foot at *Hull*, Sixty at *Bristol*, and Seventy at *St. Malos*: In regard that at the *First Port*, our *South* and *North-British* *Currents* redouble their languishing *Forces*, by their mutual *Occurrence*; at the *Second*, the *Severn-Sea* gapes with so wide a *Mouth*, to drink in the *Ocean*; and swallows it down so narrow a *Gullet*, to raise the *Tide* to a *Height* extraordinary; and at the *Last*, the *Bay*, with a stretch'd-out *Arm*, takes in near a *third Part* of our *South Channel*, and brings it almost to a *Point* at *St. Michael's Sea*, to exalt it above the rest.

And in regard the *River Garrone* can contain *two Floods* at once, having a streight *Channel*, with *Length*, *Breadth*, and *Depth*, capable of 'em; we need not wonder, that *four Tides* shou'd be kept on foot at once, in the *Sea*, at much farther distant *Places*; as at the *Equator*, *Plymouth*, *Hull*, and *Amsterdam*; still pursuing one another, at twelve *Hours* distance, as it were from *four* several *Stages*, upon the same *Road*.

As for *Supernumerary Tides*, which happen
 ofner than twice every twenty-four Hours,
 in

in the same Place ; they are occasion'd by a *Division* of the common Tide, passing into the same Gulph of the Sea, thro' *distinct Channels* ; and of so unequal Speed, that the one may Flow and Ebb, before the other arrives ; as sometime happens in our *Irish Sea*, thro' its *South* and *North Channels* out of the Ocean.

And in case a *Second Gulph* succeeds the *First*, and the Channels conducting 'em thither, *subdivide* the *Four Floods* already made, as it happens in the *Euripus* behind the *Negroponte*, to make 'em up *Eight* ; if *One* be withdrawn within that Space of twenty-four Hours, as it happens there by the Moon's Absence, only *Seven* must remain : so on the contrary, the Causes of the Tide's Multiplication being *revers'd*, an equal *Re-union* must follow ; so that *Four Tides* may be conjoyn'd into *Two*, and these *Two* be re-joyn'd into *One*, by acting Counter to each other, (as in the Port at *Tunkin*) by their different Application.

Lastly, Whereas it is observ'd, that the Course of the Tide rather adheres to the *Mean Motion* of the Moon, than to either of the *Extreams* ; 'tis because the *Ocean* which is mov'd, consisting of a ponderous, as well as voluble Element, must still hold to its own Pace : like a long *Pendulum* ; which more regards the *equal Poise* of its own Weight, than the *unequal Draught* of the Clock, which keeps its Swinging on foot.

And whereas the Swings of the Tide mostly continue to *rise higher*, for some Days, after the *Change* and *Full* ; as *January* is mostly colder than *December*, and *July* hotter than
June,

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June, after the Sun has left his highest and lowest Stations: 'tis because, in all three Cases, the *active Power* of the Sun and Moon decreaseth less than the *passive Resistance* in the Subject Air and Water doth, to hinder the Encrease of the Effect.

So fully are resolv'd the diverse Appearances of the Tide, in all *Seas, Rivers, and Lakes*, within the Compass of our Acquaintance: and doubtless the Rest, thro'-out the Universe, so far sympathize with ours, as to be resolvable upon the same Grounds, with equal Satisfaction: And altho' the Matter thereof, being *physical*, may seem to include Obscurities; yet the Form, which is Local Motion, stirr'd up by *Trusion*, properly belongs to *Mechanical* Consideration, which admits no Doubt, when the Matter of Fact is manifest to Sense and Experience. Hence it is to be inferr'd, that the *active Power* of the Sun's and Moon's Pressure, being proper to raise it; and the *passive Dispositions* of all those *Seas, Rivers, and Lakes*, adapted to receive it's different Impressions, in the Places aforesaid; the Effect must needs follow, as to its Substance, upon their due Application. Tho' in what Measure (the Ocean, whence it first springs, being unfathomable; and the Air, which conveys it, how compressible not yet known,) be left somewhat uncertain.

S E C T. XIII.

The CONCLUSION:

Wherein the Modern Doctrine of Attraction, and its Fitness to explicate the Phenomena of the Tide, is considered.

HAVING in the preceding Chapters deliver'd my own Thoughts concerning both the Causes and Effects of the *Tide*, as far as I could find them warranted by Observation and Experience, the best Guide of Speculation: I thought to have shut up my whole Discourse with the brief Recital and Explication of such *anomalous Motions* of it, which seem'd the most unaccountable; without engaging my self in any Controversy, or meddling at all with the different Sentiments of others.

But this grand Principle of *Attraction*, which so successfully has been made use of, by the most celebrated Philosophers of this Age, in solving some of the abstrusest and most important *Phænomena* of Nature, being apply'd to this also of the *Tide*; makes it necessary, before I put an end to this Treatise, to subjoyn some few Reflections on its Sufficiency to produce the desired Effect, as well as its Agreeableness with constant Observation and Matter of Fact.

And *First*, Whereas it is confess'd on all Hands, that the *Moon* has a much greater Share in raising the Tidal Tumour, than the
Sun,

Sun, which far exceeds her in Magnitude, purely with Regard to her greater *Vicinity* to the Sea: To argue consequently upon the same Grounds of *Attraction*, it must be concluded, that our *Terrestrial Globe*, thro' the great Advantage of its Bulk, (its Mass of Matter being to her's, nearly as 26 to 1) and its close Approximation to the Ocean, must, by a just Computation, be much more enabled to *restrain* the said Tumour, than the Moon's *Attraction* can possibly be to *raise* it.

2dly, To make *two* Floods diametrically opposite to each other with one diurnal Revolution: we have shewed; how the *Rising* Moon gradually depresseth the Sea into an Ebb, between the *Tropic's*, 'till her Southing: The Water so depress'd correspondently advancing all the while *two* Floods, collaterally beyond 'em, upon the *same Meridian*: Each of which, by falling, in the next six Hours, into an Ebb, fetcheth itself up, by *Libration*, upon the *Equator*, to the *same* Height, at her *Setting*: And six Hours after, returns at Midnight, by *Counter-libration*, to the *same* Point whence it first came; to counterpose, at 12 Hours end, the Flood, which is rais'd by her Pressure with the *Antipodes*; both hap'ning, in diametrically opposite Points, at the *same* Instant. And the like *Contraposition* must be concluded of all the Floods and Ebbs within or without the *Tropics* respectively. But now to make High-Water in both Places at once, by one single Draught of *Attraction*; maugre its Reluctance, and the Water's *Centripetal* Tendence, joyntly hindring its being rais'd on the contrary Side;

Side ; and this without calling in the Assistance of Tidal *Libration* and *Restitution*, to continue a *Counter-motion* in all Places, and at all Times respectively, seems to me inconceivable.

3dly, Besides the Consonancy of this Succession of Ebb and Flood (by *Libration* and *Counter-libration*) to the Laws of *Statics* ; it gives, moreover, but little or no Disturbance to the *Sea* or *Navigation* : For, in regard the Rise of the Tide above the Ocean's common Level, near the *Equator*, scarce exceeds six Foot, as has already been observ'd ; and its Ebb's *Depression* sinks only so much below it ; and their Rise and Fall beyond the *Tropics*, can be no more than answerable thereto : And again, the Motion of the interposing Sea, to supply the Extremes, is still proportionate : Hence, no part of it needs move faster than about 6 Foot from its Fellow in 6 Hours Space ; the whole Body of the Ocean's Water moving together at the same *slow* rate : So little Disturbance doth the Tide give to the *Sea* itself, or Impediment to *Navigation*, in either respect ; whereas *Attraction*, by drawing the Surface of the Sea toward the *Equator*, and letting it fall back again toward the *Poles*, reciprocally ; causeth such a progressive Determination in it, as must needs put the *Ship* quite out of her Road, at so vast a Rate, as to render the Art of *Navigation* impracticable. Add to this, that the Figure of the Earth being suppos'd that of an *oblate Spheroid*, and its Diameter toward the *Poles* shorter than toward the *Equator* ; the Water of the Ocean, rais'd by the Moon's *Attraction* be-

between the *Tropics*, wou'd descend by its own Weight, after the Force of that Attraction was over, with a Degree of Acceleration proportionate to its Access toward either *Pole*; which must occasion yet farther Inconvenience to the Sailor.

4thly, The Moon's Course holding perpetually between the *Tropics*, or near unto 'em; the Force of her *Attraction* shou'd draw the Flux of Tide constantly that Way; and withall, she passing successively from one Meridian to another, it shou'd respectively attend her thither: Besides, the Lines of her *Attraction*, the shorter and more perpendicular they grow, their Operations shou'd become the more powerful; and the farther the Flood follows its Draught, the higher it shou'd be advanc'd; whence it must needs follow,

1st, That the proper Tendency of the Tide shou'd drive it from *East* to *West*, and its Waves be still more accumulated to the *Westward*; whereas Experience tells us, that the Mariner suffers not the least Drift of his Ship that way, save by the *Trade-Wind*, which floats on the Surface of the Water; whilst the Tide dives into the Deep, and keeps its Stages in the Ocean, under Water, *North* and *South*, without the least Impediment to his Voyage.

2dly, That High-water should always attend the Moon's Motion, from *East* to *West*, around the Globe; and that it shou'd be Flood every where, when she is actually present upon the Meridian of the Place: Whereas, it has been made appear, by divers Instances, in the foregoing Treatise, that it is constantly

stantly both High and Low-water *at once* under the same Meridian, tho' in far distant *Climates*; that is to say, Low-water between the *Tropics* and the *Equator*, while the Moon is actually present there, to stoop it by her Pressure; when it is High-water between the *Tropics* and the *Polar Circles*, under the same Meridian, by way of *Result*, at a farther Distance from her.

3dly, It must also follow hence, that it should flow higher at the *Tropic of Cancer*, being more South, than at the *Streights of Gibraltar*; and at the *Caribees*, which lie most *S. West*, than in any other Part of our *North Atlantic*; quite contrary to all Observation.

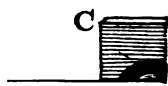
At least, highest Water shou'd constantly happen where the *first Meridian* intersects the *Equator*, when the Moon is actually near the same Point, to give her attractive Power the best Application: The Subject Ocean, being there equally dispos'd to receive the Effect, by the greatest Liberty of Sea-room possible to produce it: Yet on the contrary, there, and then is found the lowest Ebb: as has been proved from the best Accounts of *Navigators*, and their *Tide-Tables*.

Lastly, Altho' it cannot be denied, that the Tidal Tumour may be caused by *Allevation* as well as *Depression*, as has been already noted: Yet, in regard, *Attraction* is no other than an occult Quality, whose Operation being unexplicable from any of the known Laws of Motion, (especially by such who maintain the Necessity of *Vacuties*) is to be resolv'd merely into the Omnipotent Will of God; and therefore much less accountable for than

TRU.

TRUSTION, which is visible to the Eye and tractable by the Hand : I hope I may obtain a more easy Pardon from those excellent Persons, who in the Earnest Pursuit of Truth have been led into a different Sentiment. In this Matter I have had Recourse to Precept alone : Which is manifest to Sense ; whose Effects are undeniable ; and which answers all the *Phænomena* of the Subject I have endeavour'd to explicate.





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12



A Clear and Succinct

DESCRIPTION OF AN ENGINE

Which fetcheth

WATER out of the Deep,

AND

RISETH *it to the Height design'd,*
Progressively, by the same Motion.

CHAP. I.

TO render the proposed Description more intelligible; for Method and Clearness, the whole Discourse is divided into Three Chapters, or Books: The *First* whereof, declares the several Perfections and Advantages of this Engine:

Description of an Engine,

The *Second* discloseth the Defects, and Impediments of others: The *Third*, shews how the Perfections of the former, correct and supply the Defects of the Latter: And each of these is subdivided into Four or more Sections, or Paragraphs, as the Matter shall require.

S E C T. I.

Of the plain Construction of the Engine; the Use of its several Parts; and their Proportion to the Quantity of Water, which is to be rais'd.

THE Frame (*Fig. 1.*) which sustains the Work, consisting of two Plates, (*A, B, C, D,*) rais'd upon four Pillars, like a Plate-clock, contains within 'em a Central-wheel; whose Rotation, by the Help of four Ladles, (*Fig. 2, R, S, T, V*) passing successively thro' a Channel *V, T*, for a Quadrant of its Circle, from the Perpendicular to the Level of its Axis, both sucks and protrudes the Water Progressively, out of the lower *Z* into the higher Tube *X*, affix'd respectively, by two Muzzels, to the Outside of the said Frame; which also contains a Claugh, that, being open'd by the Forcers, at their Entrance into the Channel, is shut again after 'em, by a Spring, to hinder their Stream from returning, which are all the Integral Parts, belonging to the Engine; and these are the Uses they are put to.

Now, concerning the Size of the Parts of the laid Engine, in Proportion to the Quantity of the Water, which is design'd to be rais'd: The *First* Consideration, which leads to all the rest,

is, to find by Experience, a Tube of what Bore, will carry off the design'd Stream at a competent Rate, to give Satisfaction; and if one, for Example, of four Inches diameter, will serve the Turn. *Secondly*, The Channel is to be wide and deep enough, to supply it; and being expediently wider than deep, near five Inches hollow will be required: And *Thirdly*, Ladles must be of the same unequal Breadth and Depth, to fill it so exactly, as, in some measure, to hold Water; and allowing for the Sides of the Channel, one Inch more. *Fourthly*, The Pillars which raise the Plates, to contain the whole Thickness, must be six Inches at least: So that if the Tube be four Inches, the Channel must be five, and the Frame six Inches wide; as is manifest.

Lastly, Altho' the Ring of the Wheel must necessarily be as broad as the Ladles fix'd upon it to sustain 'em, and fill the Orifice of the Channel so closed, as to let no Water leak out; and withal of so large a Compass, as to allow a proportionate Distance betwixt its four Ladles, to hold a Competency of Water; yet it is to be enlarged upon Occasion (and consequently the Plates of the Frame also) to whatever compass, the Force and Speed of the first Motion shall require: And still the stronger and slower this is, the Wheel must be larger in Proportion, to keep an equal Pace to the design'd Performance in all Cases: Such is the Proportion of every Part of the *Engine*, to the Quantity of Water, in all respects: And

So exactly is the whole Series of the Parts of this *Engine*, adapted each to other; and the Size of 'em all is so proportion'd, to the
Quantity

Quantity of the Stream they are to manage; and comparatively thereto, so small and minute, and withal so close compacted together; that the whole Frame of 'em needs not to exceed two or three Foot in Height, and as much in Breadth; and eight or ten Inches in Thickness, to supply any Use; yet the larger the Engine is, the Performance still proves more effectual, with Regard to the Force apply'd; whether the Quantity of the Water, or the Height whereto it is advanc'd, be consider'd. Now its Organical Parts being all so well prepar'd for Action, let us proceed to shew the Efficacy of its Operation.

S E C T. II.

Concerning the Ease, and Efficacy of its Operation.

FIRST, Since all Motion is suppos'd to begin from Rest, and to encrease by Degrees, till it arrive to some determinate Speed; hence, Water is rais'd by the said Engine with the greatest Ease, gradually, from its horizontal Position, up the Quadrant of a Circle, till its vertical Motion becomes Perpendicular; and having attain'd to its utmost Speed successively, the forcer that rais'd it leaves it.

Secondly, As a single Force is the best; the forcer which raiseth it (for Example, the Hand of the Artificer) lays fast hold on *H*, the Handle of the Turn, which is immediately join'd to it, and moves together with it; without the Interposition of any Obstacle,

to fetch Water out of the Deep. 213

to hinder or weaken their joint Motion; and consequently they perform their Lift, to the best Advantage.

Tbirdly, The Motion of the Water upward, being render'd Perpendicular, by the Curvity of its Channel *V, T*, still inclining it that Way, its Stream passeth freely into the upward Tube *X*, (*Fig. 3.*) which is plac'd just over it, and is of the same vertical Tendence; and is carry'd upwards ever after, according to this its first Direction; the better to preserve the projectile Impulse, already impress'd into it.

And not to suffer its upright Motion to cease, or intermit, another Ladle of Water is immediately thrust up into it after the former, by the succeeding Forcer; and so one after another, quarterly; four of 'em *R, S, T, V*, being affixt around the Ring of the Wheel (which shuts up the upper Side of the Channel) at equal Distances; to come all in play successively at every Revolution, and render their Performance perpetual.

Fountbly, As the said Forcers, passing successively thro' the Channel, push up each its Portion of Water into the upper Tube, to be carry'd off at the Height design'd: So respectively, by the same single Motion, each sucks up a proportionate Stream from the other Tube *Z*, fixt at the lower End thereof; the Ponderation of the Atmosphere, forcing up (by its Pressure upon the Superficies of a Pond, or River underneath) a competent Portion of Water, to supply the Evacuation: Thus each Forcer at once, pusheth one Portion of Water before it, and sucks another Draught after it. to make the Supply, as well as the Evacuation, successive

cessive to a Perpetuity; with all the Speed, and Expedition imaginable. Now

Fifthly, To hinder the Motion of Water from circulating (together with the Forcers which drive it) thro' the Body of the Engine, out of the upper End of the Channel, back again into the lower, to perfect the Circle.

First, On the trusive Part; when the Stream, which is thrust up the Channel, has fill'd the Body of the Engine, it can follow the Motion of its Forcer, no longer that Way; where all is full to obstruct its Passage, and so is compell'd to ascend into the higher Tube, X, where it finds vent upwards, according to its present Direction; and mounts more freely, by the Energy of its former Impulse, and with most Ease thro' Water, as being of the same fluid Constitution. Nor

Secondly, Can the said Repletion be evacuated downwards, on the Suction Part, into the lower End of the Channel; its Orifice being shut up so close by a Claugh, after the Forcer's Entrance into it, that Water cannot follow it that Way; and consequently, the Ladles pressing forwards into the Channel, must needs leave a Vacuity therein behind it; to be supply'd from below with Water, by the Pressure of the Atmosphere, as aforesaid; to keep the Suction on Foot, as well as the Protrusion, that the Operation, on both Parts at once, may be render'd compleat.

S E C T. III.

Of the great Force, and large Extent of this progressive Engine's Performance.

TO calculate the utmost Reach of its Performance, both in Respect of Force, and Extent; First, from the Quantity of the Water which it is capable to contain; Secondly, from the Height it is able to advance its Stream, with Regard to the Force employ'd to raise it, and the Space of Time, wherein the Work is to be accomplish'd; it is to be consider'd,

First, As to the Quantity of the Stream; a greater may be rais'd, progressively, by this Sort of Engine, with Regard to the Smallness of its Size, than can be expected from any other; as requiring to be no thicker, than to contain a Tube of as large a Bore, as will suffice to convey the Current with a free Passage; nor of a greater Compass, than to include a Wheel of a competent Circumference, to admit of four Ladles at a porportionate Distance from each other, to hold Water enough, as corresponding to their Height, and Breadth, while it is turn'd by a weak, and quick Hand; But in Case the Motion be strong, and slow, as is a Water-Wheel; this of the Engine may be enlarg'd, to keep Pace with it, without any Alteration in other Respects.

Secondly, Concerning the Height, to which the Effect of this Engine extends; since it

A a may

Description of an Engine,

may fall short of its Pitch, either, First, by the Loss of too much Water, from the Pressure of that Height; or, Secondly, the Force of the Mover may be as much weaken'd by Friction; these two Rubbs are to be remov'd out of the Way.

First, As to Loss of Water, from Pressure at any Height; since the Bulk of it is encreas'd according to all its three Dimensions, at once; much more proportionably to its Surface, than can possibly be squeez'd out of its Substance; especially, in Regard the Work in a large Engine, may be as close jointed as in a small one: Hence, this Sort of Engine must needs be the least Sufferer, of all other in that Kind; which is capable of Enlargement, without Limit, and may contain any Quantity of Water, whatsoever.

Besides, since the upper and lower Tubes, are suppos'd to be affix to the Box which includes the Engine, so closely as to hold Water all along from the Top to the Bottom; and not one Drop can issue out of the Channel into it, which is fill'd already and the higher the Water is rais'd in the upper Tube, the greater is the Box's Reluctance to receive more: Hence all that is spilt, must fall back again down the Channel into the lower Tube, which cannot be considerable, tho' the Pressure be never so much advanc'd; being shut up, both at the End, Bottom and Sides, by the Clough and Forcers, as close as is possible.

Thirdly, provided the Force, which is design'd to lift any Quantity of Water, be proportion'd to its Weight; no farther Regard is to be had to any incidental Friction of the Forcers

Forcers upon the Sides and Bottom of the Channel, or occasional Reluctance of the Claugh, to open and shut; their Contrivance being such, that no Weight of Water whatsoever, can harden the former upon 'em, or deflect the latter in the least either Way; nor add to their Friction in any other Respect, than what properly belongs to their Axis, which is always allow'd, and scarce accountable.

Lastly, To assign a competent Space of Time for the whole Performance; Suction being the first Step towards it, and Trusion the last; Nature itself (the Air being evacuated) makes the former *Gratis*; the Weight of the Atmosphere buoying up the Stream in the lower Tubes usually, four or five Yards, on its own Accord; while Art accomplisheth the latter, by applying the Power of the first Mover to the Forcers themselves; so speedily and effectually, as to lose neither Time nor Labour: One Gulp of Water, pushing successively another upwards before it, with the same Vigour and Celerity, no retarding Obstacle being permitted to interpose.

And forasmuch as to force any Quantity of Water to a determinate Height, with an equivalent Power, and a proportionate Space of Time, by pure lifting, without any sensible Impediment of Friction, &c. besides the Weight of that dull Element, is all that Nature will allow, or Art can contrive; it remains only to be try'd, how this Theory will come off in Practice, with a commodious and serviceable Application.

S E C T. IV.

Of its suitable and commodious Applicability, to all Kinds of Uses.

THat this Progressive Sort of Engine may be more commodiously to all Uses, on every Occasion; it may be turn'd indifferently, either by Wind, or Water; Horses, or Mens Hands; and by these either jointly, that is, by two, three, or all four ways at once; or by each severally and apart, in different Circumstances.

First, To fetch up its Stream out of the deepest Mines, by the Help of Gynn-Work placed above-ground; either Wind, Water, or Horses are serviceable enough: But Wind join'd with Horses, (so far as both move horizontally) suit best together; the former, to force; and the latter, to regulate their joint Motion; the Wind, by heightning it at every Blast; and Horses, by abating it again to a constant rate; and holding out better (by the Ease of those repeated Blasts) for whole Days at once, than to be kept to the utmost Stretch of their Draught (as is usual) for two Hours Space together.

Secondly, It serves as well for draining Fens, and marshy Grounds; and is turn'd either horizontally, or vertically, by the Impulse of the Wind; and being capable to be enlarg'd at Will, in Proportion to the Sails that drive it, 'twill discharge any Quantity of Water whatsoever; and the greater it is, still the better indefinitely, if all things else be proportionate.

Thirdly,

Thirdly, It is no less accommodated to Ships of any Burden; its Bulk being small, and Parts compact, to be easily manag'd; and withal its Figure, cubical, to be fix'd wherever it is placed; and may be ply'd by many Hands at once, to do the Work of as many Pumps, with one single Motion; and may be play'd either above Decks, where Suction alone will suffice, as in Merchant-Ships; or else in Men of War below 'em, by the Help of Protrusion added thereto, to keep both itself and its Managers out of Gun-shot; and if the Top of its Tube chance to be knock'd off above Water, it may be as easily supply'd by another, as a Candle may be set in a Candlestick.

Fourthly, It is able to supply Towns, Castles, &c. of the loftiest Situation, at one Lift; and to furnish 'em with a competent Stream, by one and the same single Motion; encreasing its Force, and exhibiting its Capacity, at once, by all the Manners and Means above-mention'd: But to the greatest Advantage, and with the most effectual Application, when it is turn'd by a Water-Wheel, so proportion'd to its own, that both may move concentrically together at the same rate; their Axes being so conjoin'd by square Hoops, that each may carry the other along with it, without any interposing Impediments; which, being all remov'd, leave no Possibility for Art or Industry to improve the Operation, or heighten the Performance.

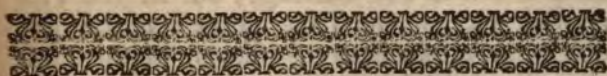
Lastly, One, and the same individual Engine may, on Occasion, be convey'd from Place to Place, to supply those several Offices successively, and be fitted and refitted for Service,
in

Description of an Engine,

in a few Hours Space: And, whereas others seldom exceed five Tuns *per Hour*, to twenty Yards; this may raise fifty Tuns in the same space of Time, full fifty Fathoms; yet neither for Bulk, nor Weight, exceed a Waggon-Load.

Such are the distinguishing Perfections and Advantages of Operation, Performance, and Application, which this Progressive Machine performs above the rest, that none can reach it in any respect: But to make 'em more remarkable, by the contrary Defects which these sustain, and the Impediments wherewith they are pester'd, and render'd less effectual; they come now to be recounted, and deliver'd in their natural Order, in the next Chapter.





CHAP. II.

Of the Impediments, and Defects of all Water-Engines, the Progressive Sort excepted.



Since all the Disadvantages of other *Engines* are manifestly occasion'd by their several Deviations from the aforesaid Progressive Tract, which is the shortest, readiest, and of best Performance possible: They are (for Brevity and Clearness) to be recounted as such; by shewing at every Step, how they deflect from it; and what Accident occasion'd it, in a kind of natural Order.

SECT. I.

First, In regard we find Buckets to be of greater Antiquity, for drawing Water out of Fountains, than Pumps; and to be of more Plainness, and less Art: We begin with the Consideration of Gynns, and Whimseys that make use of 'em; and it is to be remark'd for their Advantage, that they spend too much Time in Filling and Emptying, to be expeditious: Whereas the said Progressive *Engine* is always full, and overflows, so as to lose no Time on either Account. Again, If their Lift be taken from a great Depth, much of their Load

Load is lost in the Carriage; but in the Progressive Way, if the Tube prove staunch, not one Drop is spilt from the Bottom to the Top; afterall, their alternate Returns are unmanageable, either by Wind, or Water; whereas this Sort complies with both, either together or apart.

Secondly, The Churn-Pump, which is the plainest, and most commonly used, altho' it both sucks and lifts its whole Stream, from Bottom to Top (as the Progressive does) at every Stroke; yet withal it intermits half its Time in both Respects, while its Sucker stoops to fetch up a new Supply, for which the Progressive Forcers have no Occasion.

And the Chain-Pump, in a farther Accord with our *Engine*, at one Draught both sucks and lifts its whole Burden, with a continual Progression; but withal is so choak'd up with its Saucers, and overloaded with its Chain, both which so rake the Inside of the Tube, from the one End to the other, that 'tis but of a scant and heavy Performance: Whereas in ours, one Ladle of Water incessantly forceth up another, without Intermission.

Thirdly. Concerning Trusive-Pumps, which drive the Water downwards, to fetch it up again by Rebound; they are disadvantageously made use of by *Water-Engines*, as being design'd solely for raising its Flux, from some lower Situation of Ground, up to a higher: For, by this Means, half of their Labour is lost, as well as their Time; the greatest Part of their Force, being discharg'd against the Bottoms of their Troughs; and the briskest Part of their Pulses being broken by their Repulse from 'em, before the
Re-

Result of the Stream, can be considerably re-advanced.

Nay, the Pulses of those Protusive Pumps being perpendicular, and the Motion of the impell'd Streams suck'd into their Cylinders, and push'd out again, Horizontal; much of the impress Power is lost, both those Ways: As an Arrow, by every Glance, loseth both its Strength and Speed; and a Cannon-Ball, after the first Graze upon the Surface of Water, can do the adverse Ship little Harm: So the Forcer, being depress'd by a curv'd Line, must stagger all the while, and give but a stumbling Stroke after all: Whereas in the Progressive Way, the Forcers, how crooked soever the Channel be, which conveys the Water out of the lower Tube into the higher, (their Motion being circular) still pursue their Streams at rights, thro' the same Path; without the least Diminution of their Pulses, to render 'em less effectual.

Fourthly, Forasmuch as every Ounce of Weight, added to the Forcer, requires an Overplus of Strength, to fetch it as speedily up again: Hence it is a great Mistake, to beat down the Water with pondrous Malls, to make a correspondent Result; and meely serves to redouble the Forcer's Misapplication, to brandish each Log of Wood in the Air, instead of affecting the Water more effectually: A Method much different from our Progressive Conduct, whose Engine-Wheel is light, and equiponderous on all Sides, and every Ladle hath its Opposite for a Counterpoise.

Fifthly, When those solid Hammers are exchanged for hollow Cylinders of Metal, to slide gently up and down at every Stroke, the one

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within

within the other; if the Motion be single, it loseth, as abovesaid, half its Time and Labour; and in case it be double that the Forcer, at the one End of their Libration, may push, while the other withdraws reciprocally: However, in the Interval of their exchange of Offices, their common Stream is left at a stop, for a redoubled Force to restore its former Speed; which gives a sudden Jerk to the Tube, which must be fortified to sustain it: A Counter-buff, not incident to our Progressive Conduct.

And, if the said Pumps be multiply'd, and the Stream be divided respectively, to render their common Current perpetual, and constant, by a regular Confluence of their Rills, to replenish it; yet withal, by intermitting as successively, to operate one after another, they become a more constant, and lasting Impediment; every one of those Rills, how small and minute soever; holding the first Force in suspense, in reference to its one Part, while it expects a new Supply of Stream, after every Stroke: Besides, the great Difficulty to drive 'em singly each thro' its slender Pipe, their Friction and Adhesion to its Sides, being encreas'd in Proportion to their Surface, from their manifold Division; which the Progressive Turn never requires, being capable to hold any Quantity of Stream, and to manage it without Intermission.

Finally, To have Recourse to Plurality of Lifts, in any Case, is a false Step; since one single Progressive Engine wou'd, at once, mount the largest Stream, to the greatest Height, with least Labour: Again, to prepare a new Engine for every Lift, would (besides the Pains and Charges)

Charges) have the Energy of the first Impulse, to renew at every Turn; and to stretch it beyond its stinted Pitch, were to accumulate all the aforesaid Incumbrances, till they became insuperable: And to be acquitted from 'em on any other Account, wou'd be a Task impracticable; since the best of every Sort, have been ever obnoxious to all, or most of those Rubbs, as will plainly appear by the following Instances.

S E C T. II.

How obnoxious the best Water-Engines, of other Sorts, are to the above-mention'd Impediments; shewn by Examples.

TO Instance those Two *Water-Engines*, which chiefly furnish the Capital Cities of our Nation, *York* and *London*; which were doubtless accounted the best extant for that Purpose, when they were made; and that stupendious one, at *Marley*, which the World so much admires.

It is remarkable, that all Three stumble, at the first Step, upon Trusive-Pumps; which, like Boat-Men, look one Way, and Row the other; and spend the Briskness of their Strokes against the Bottoms of their Troughs, before their Streams (which are beaten downwards at rights) can make their Returns upwards again, by Result; which, being but a Secondary Motion, must be both retarded and enfeebled by the Repulse.

Description of an Engine,

First, As to that at *Tork*; beside the Awkwardness of its Strokes, to brandish Three Loggs of Wood, of 1000 Pound Weight a-piece; as their Weight little avails to sharpen their Force (the Crank they hang at, having a Counter-Poise of equal Weight on the other Arm, to hinder it;) yet their Equibrity lessens not their Weight, nor awakes their sluggish Reluctance, to be toss'd up and down at once, by the same Motion; which is retarded at all Times, both Ways alike.

And, whereas that Machine under *London-Bridge* (beside the Weight of Water which they engage to raise) has Sixteen Pumps, to be hoisted up and down at the same rate, by every Revolution; so much to the Disadvantage of its Performance, that, as the one, without those Pumps, wou'd raise more Stream with one Water-Wheel, than it does at present with two; so the other, without those Loggs of Wood, would do more with two Horses, than it does now with seven.

And what additional Pains a *Water-Engine* must take, to advance its Task to so great a Height, as to require more Lifts than one; and how it is to be accouter'd for that Purpose, will best appear by

A Description of the Water-Engine, at Marley, in France, viz.

“ It is a Machine, that, by the Force of
 “ Fourteen Water-Wheels, of Thirty Foot
 “ Diameter, forceth Water 450 Foot high at
 “ three Lifts, by Way of Protrusion; the Tubes
 “ not rising perpendicularly, but lying along
 “ the

“ the Side of a Hill; at least half a Mile in
“ Length : The Pumps are mov’d by the Help
“ of two Cranks, put upon the Axis of each
“ Water-Wheel ; which, by the Help of 2500
“ Pieces of Timber, mov’d vertically, gives a
“ Stroke of four Foot, at the Distance men-
“ tion’d, to the Pumps : At each End of those
“ Pieces of Timber, that move vertically,
“ there passeth a Barr of Iron of five Inches
“ broad, and $\frac{1}{4}$ of an Inch thick ; and there
“ passeth two of those Bars of Iron, from e-
“ very Water-Wheel, to the distance of half a
“ Mile.

So vast, and manifold are the Appendices of
this stupendious Machine, superadded to the
abovesaid Impediments; and so much Pains is
taken, to acquit its Charge at three Lifts, by
the Help of so many Water-Wheels, and of so
large a Size; as to tugg and pull, each a Pair
of those massive Bars of Iron, tack’d to a vast
Number of Timber-Loggs, backward and for-
ward, for half a Mile in Length, at every Re-
volution, with a Quickness proportionate, ’tis
scarce credible.

But withal, to fetch up three Sets of Pumps,
and stamp ’em down again with the same
Briskness, four Foot at every Stroke; and
these to rowse up respectively their lazy
Streams, with the like Vivacity, from a pro-
found Rest; the Energy of their Projectile Im-
pulse being lost, before they make their Re-
turn; this seems to exceed all Human Com-
prehension, how it can be finally perform’d.

Now, whereas the Author of the said De-
scription, after full View of the said Machine
it self, and how it operated according to every
Part;

Part; told me, that 'twas writ to let me see that the " Force was all misapply'd; and to " know my Opinion, Whether an Engine of " this Progressive Sort might be propos'd, to " raise Water to the said Height, at one Lift; " and if it cou'd be done at once, without the " Loss of too much Water, by the Pressure of " that Height; he did believe one Water- " Wheel would raise more than all their " fourteen; the Charge of Repairs being im- " mense.

To remove the sole Occasion of his Doubt, being the Loss of too much Water :

First, An Engine of this Sort, being not restrain'd to any Size of Bore, as others be, may hold Water enough; and the more, with the least Loss in Proportion, from the Pressure at whatever Height, as aforesaid: Besides, the Box, which includes the Engine itself, so shuts up the Channel from without, that no Water can issue forth that Way; and the Ladles fit it so exactly within, that as little can fall back into the Tube underneath.

Moreover, the said Box, which contains the Engine, and sustains the Pressure of the Water; and the Forcers, which drive it to its greatest Height; as also the Tubes which convey it thither, are all at once much alleviated of their Burthen; the Stream still tending Upwards, with a constant and equal Course; whilst that at *Marley*, falling into Dead-Water after every Stroke, the Jerks they suffer are insupportable.

Now,

to fetch Water out of the Deep. 233

Now, forasmuch as the sole Motive, the Observer of that vast Machine had, to let me see that the Force was all misapply'd, was to know my Opinion, whether an Engine of our Progressive Sort might be propos'd, to raise Water to that Height, at one Lift ; it remains to gratify his Enquiry, with



C H A P.



C H A P. III.

A Brief Account, how the Misapplication of the Force, in other Water-Engines, is rectified to the best Advantage in this Progressive one, here advanc'd.

SINCE *Water Engines* of all Sorts, whether they be wrought by Suction or Trusion, make use of Pumps of their respective Kinds, and apply their Force in performing their Office, after as different a Manner: To begin with those that are the most plain and simple, and proceed to the rest.

First, The Churn Pump has this Advantage above its Fellows, to suck up its whole Portion of Water, one Part of its Drought, and lift it up the other at once, by the same perpendicular Stroke; yet, notwithstanding, spends half its Time, and no less of its Current, while it stoops to fetch up a fresh Supply, to renew its Stream: A double Misfortune incident to all other Pumps, and the *Engines* that make use of 'em; as all necessarily do, this Progressive one excepted: For,

To take off this Impediment, of fetching up such Supplies by Way of Prevention, the Pressure of the Atmosphere upon the Surface of the Fountain, &c. underneath, raiseth a plentiful

tiful Stream up the lower Tube, into the Channel of the *Engine*, on its own accord; where the Forcers constantly receive it, and hoist it up progressively, into the higher; which conveys it forward to the Place design'd, with a continued Stream, from the Bottom to the Top of its Course, where it is finally disposed of to the Use intended.

Secondly, As to Trusive-Pumps, which are employ'd to force Water to higher Situations; in regard they depress its Surface, which is rais'd again by Result; the Stroke is so adverse to the intended Rise of the Stream, that the Substance of it is lost, and only the Shadow remains: And, forasmuch as the Stream is drawn into the Cylinder of the Pump, on the one Side, and squeez'd out on the other, horizontally; the Stroke being perpendicular, and transverse to the Performance, must needs retard and weaken it in a great measure: And if Weight be added to the Forcer, to hasten and sharpen its Fall; this only aggravates the Impediment, to fetch it up again.

Whereas it is remarkable, that, altho' the circular Motion of the Forcers deflects the rising Stream from its former Direction, at its Entrance out of the lower Tube into the Channel; yet withal it keeps the Flux thereof to a constant rate, without any Abatement, the Channel being a quarter of the Circumference of a Circle: And by turning about their common Axis, they pursue its Flux close, according to the same Direction; and at last restore it again to its Upright Course, with all the Ease and Expedition imaginable.

Thirdly, Pumps of both Sorts, whether they work by Suction or Trusion, suffer the Flux of their Streams to intermit; and their Currents to resettl into dead Water; not to be reviv'd without as strong a Stroke, as animated 'em before; nor to recover their former Speed, but in an equal Space of Time, nor ever to the same Degree, the augmenting Water still growing more ponderous, than to be toss'd up and down between Stroke and Stroke; and so becomes fix'd at last, by its Adhesion to a longer Space of Tube; that, after all, either the Power of the first Mover is at a stand; or the Resistance of all the said Impediments being too obstinate to be enforc'd; the Tubes, by the impetuous Jerks of their Rencounter, are broken in Pieces.

Whereas to prevent, at once, all the ill Consequences of this intermitting Distemper, the Progressive Forcers still keep their Currents alive, and to an equal Speed, let their Streams grow never so ponderous: If the Force of the Movers be heighten'd proportionably to the Weight of 'em; and if the Tubes be wide enough, the Adhesion to 'em, while the Motion is constant, and of the same Tendence (let the Height be encreas'd never so much) will do little Harm.

Fourthly, To ease the said Intermitting Distemper, but not perfect the Cure; when the main Stream is divided into small Rills, and these are driven successively in one common Channel, the Flux of the Current becomes Progressive; yet those Rills retaining each, for half its Time, their respective Intervals till their Conjunction; and all coming in play at every

every Revolution, they become jointly as constant, and as lasting an Impediment to their common Stream, as before; and exerting their Performances but one at once, they weaken and retard it to that Degree, as to reach no considerable Height, tho' never so much enforced by the Power of the first Mover.

A Truth, which the ingenious Mr. Sorocold was so sensible of, as to its first Part, that, when the small Bore of his Trusive-Pumps, oblig'd him to make use of no fewer than sixteen, to supply with Water so considerable a Part of London, he took care to reduce 'em to a four-fold Stream; and to re-unite these in one, to render the whole progressive, without Intermision: And that the Water might rowl with more freedom within itself, up a Tube of the largest Capacity: This, I say, gave Ease to the aforesaid intermitting Distemper; and sufficiently accommodated his *Engine* to a London Situation, that required not above twenty or thirty Yards of Height, to furnish it: But to have perfected the Cure to a hundred Yards higher, he must have re-united all his sixteen Streams into one, and his Pumps accordingly, for the same Reason: For

Finally, It was found more feasible at Marley, to raise Water by Protrusion, 450 Foot (or thrice fifty Yards) at three Lifts, with so many Ranks of Pumps, and by the Help of twenty eight Barrs of Iron, and 2500 Pieces of Timber; than to encounter a Complication of all the aforesaid Impediments, at a greater Height than fifty Yards at a Lift: For, altho' each of 'em apart, had necessarily either diminish'd the Quantity of the

Stream, or cut short the Height whereto it ought to be rais'd; yet more Force wou'd, in some measure, have surmounted the Difficulty; but all being combin'd to enforce one another, wou'd have render'd the Operation impracticable, in every Respect, by any Mechanical Power whatsoever.

How much more expedient had it therefore been, for saving of Time, Labour, and Charges; to have waved all Thought of so awkward intermitting Pumps, as pester'd that Work, with such useless Lumber of Iron, and Timber, that attended 'em; and instead of 'em to have re-assumed a Tube, capable of holding their whole Stock of Water; and a Water-wheel of Force, to raise it to that stated Height at one Lift; by the Assistance of a suitable *Progressive Engine*; which, being rid of all the above-mention'd Impediments, wou'd have had nothing left, beside Weight of Water, to have supported, and struggl'd with.

This being suppos'd, the Quantity of the Water, and the Height of its Advance, wou'd have held this Proportion to the Force apply'd; that, if one Horse cou'd raise ten Ton per Hour twenty-five Yards (which is practicable,) two Horses wou'd raise the same fifty Yards; four Horses, a hundred Yards; and six Horses, a hundred and fifty Yards; which is the stated Height at *Marley*: And this Computation, being transver'd; to what Height one Horse wou'd advance ten Ton an Hour, two Horses wou'd lift twenty Ton; three Horses, thirty Ton; and so progressively: So that the six Horses, which rais'd ten

Ton

Ton per Hour, at *Marley*, doubl'd, wou'd furnish twenty Ton per Hour; eighteen Horses, thirty Ton per Hour; and twenty-four Horses, forty Ton to the said Height: And, if the Force of twenty-four Horses, be equivalent to that of one Water-wheel of thirty Foot Diameter; it wou'd raise as much Water, as fourteen do at present: But the Quantity actually rais'd there, and this Equivalence being unknown, we are still left in the Dark: But if it be true (which is credibly reported) that the whole Stream is convey'd from *Marley*, to *Versailles*, by a Tube of only eight Inches Bore; we may rest well assur'd, that an Engine of four Foot Square, and one Foot thick, wou'd suffice to raise the same from the River *Seine*, at the Bottom of the Hill, up to the Top of it; the Force, that at present is employ'd to do the Jobb, is so wholly misapply'd.

Finally, Forasmuch as the first Chapter of this Treatise, hath display'd the distinguishing Perfections, and Advantages of this Progressive Sort of *Water-Engines*, above all others, viz. The unparallell'd Plainness and Compactness of its Structure, the Ease and Efficacy of its Operation; the large and boundless Extent of its Performance, and commodious Application to all Manner of Uses: And the two following Chapters, have disentangled and freed it from all those Defects, and Incumbrances, incident to all the said Sorts, to their great Disadvantage, and prejudice in all those Respects:

spects: It remains to conclude, That it is the absolute Master-piece of the whole Art and so compleatly perfect in every respect as to be capable of doing our Nation better Service, both by Sea and Land, than all the rest.



F I N I S.





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